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FEASIBILITY STUDY OF HIGH-SPEED RAIL IN THE UNITED STATES OF AMERICA

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"FEASIBILITY STUDY OF HIGH-SPEED RAIL IN THE UNITED STATES"

ABSTRACT

The most basic and outstanding argument for High-Speed Rail (HSR) in the United States (U.S.) is the pressing global environmental crisis, and the role that the U.S. plays in it. The U.S. contributes to environmental problems in a proportion that far exceeds its share of the world's population, and transportation is a major component of the problem. The U.S. transportation sector finds itself locked into a heavily fossil-fuel dependent infrastructure. The Interstate Highway system is now in danger as a result of age combined with overuse in many stretches; the U.S. airline industry is struggling to meet demand on many routes. The U.S. needs a smart transportation system that would satisfy the demands of the 21st century, a system that reduces travel times and increases mobility, a system that reduces congestion and boosts productivity. A HSR system would address these concerns while adapting U.S. infrastructure to future transportation needs. HSR would reduce traffic from the American highway infrastructure, and would reduce the airline congestion.

Today, the U.S. is quite disposed for HSR, but a correct definition of the corridors that are most appropriate for HSR service, is critical to the long-term success of America's HSR program. To date, ten HSR corridors have been designated by the U.S. federal government. Given the early stages of these projects, "success" cannot be based on implementation, but is defined in terms of whether a given HSR project is still actively pursuing development and funding. With the exception of the Northeast Corridor (NEC) operated by Amtrak, there has been relatively little forward movement if one looks at the number of years spent on many of these projects. The federal government has played and continues to play a minimal role in HSR projects, generally restricting its efforts to funding pilot studies and technological research. It is convenient to think that projects of this scope will likely necessitate financiers to rise to the occasion, and develop innovative public private partnerships funding schemes with adequate types of contracts involved on the various stages of design, construction, and operation. When cost-benefit analyses are developed for HSR in the U.S., the focus tends to be on how much money will be put in and how much will be generated. Looking on this way, it is unlikely to see HSR implemented in the U.S. because of the large capital investment needed to build such systems. If something has to be clear, is that the HSR in U.S. is a solution that has to be seen more adapted to the economic future of the U.S. rather than its present and broader tabulation that includes non-monetary benefits (such as reduced congestion on the alternative modes or reduced environmental impacts) have to be taken into account.

A project of the magnitude of national HSR would undoubtedly not be without its critics. Many are decrying additional government spending while others see the complexity as insurmountable. Opportunities for both incremental and new HSR exist in the U.S. along those corridors federally designated as HSR corridors. The key is to get at least one project fully implemented in a way that is clearly HSR (as opposed to those that are capable of high speeds but only run at such speeds for small distances). Once a project is in revenue service, many of the concerns expressed by critics (including ridership projections and whether HSR can work in a country where cars and air transport are dominant) can be addressed.

The implementation of internationally recognized HSR technologies from European and Asian countries like Japan, France or Spain, and the study of their experience with HSR transportation and its economic and technologic viability, can serve the U.S. as the best example to introduce the most sustainable existing massive mode of transportation. The U.S. therefore would be able to show to the world that the country that invented the largest and most developed networks of roads and air transportation is also able to develop the most advanced HSR system to take a turn to a better world.

“FEASIBILITY STUDY OF HIGH-SPEED RAIL IN THE UNITED STATES”

RESUMEN

La argumentación más relevante para la alta velocidad en los Estados Unidos (EE.UU.) es la presión mundial ante la crisi medioambiental y el papel que el país juega en ella. Los EE.UU. contribuye a los problemas ambientales en una proporción que supera con creces el porcentaje del resto de población mundial, y el transporte es un componente importante de esto. El sector del transporte en los EE.UU. se encuentra encerrado en gran medida a los combustibles fósiles y a la infraestructura dependiente de ellos. El sistema de autopistas interestatales se encuentra en peligro sin embargo, como resultado de la edad combinada con el uso excesivo a lo largo de muchos corredores, y la industria aérea está luchando para satisfacer la sobredemanda de pasajeros en muchas de sus rutas. Los EE.UU. necesita un sistema de transporte inteligente que iguale las necesidades del siglo 21. Un sistema que reduzca los tiempos de viaje y aumente la movilidad, un sistema que reduzca la congestión y aumente la productividad. Un nuevo sistema ferroviario de alta velocidad podría abordar estas preocupaciones, mientras que a su vez se adaptaría a las existentes infraestructuras y a las futuras necesidades del país, aliviando el tráfico en las carreteras interestatales y reduciendo la congestión en los aeropuertos.

Hoy en día, los EE.UU. está plenamente dispuesto a los trenes de alta velocidad aunque la correcta definición de sus corredores es crucial para el éxito a largo plazo del programa propuesto. Hasta la fecha, diez corredores de alta velocidad han sido designados por el gobierno federal. Teniendo en cuenta que los proyectos se encuentran en fases de iniciación, el "éxito" no puede basarse en la aplicación, sino que debe definirse en si determinado proyecto sigue trabajando activamente en el desarrollo y la financiación. Con la excepción del Corredor Noreste (Northeast Corridor; NEC) operado por Amtrak, ha habido relativamente poco avance si se considera el tiempo y el gran trabajo que se ha invertido en muchos de estos proyectos. El gobierno federal ha desempeñado y sigue desempeñando un papel mínimo en los proyectos de alta velocidad, restringiendo sus esfuerzos a los estudios piloto de financiación y a la investigación tecnológica. Es conveniente pensar que los proyectos de este alcance requieren grupos financieros a la altura de la ocasión y el desarrollo de innovadoras asociaciones público-privadas de financiación deben actuar con adecuados tipos de contratos involucrados en las distintas fases de diseño, construcción y operación. Al desarrollar análisis de costo-beneficio, por ejemplo, en los EE.UU. la atención tiende a ser sobre cuánto dinero se pondrá en y cuánto se generará. Mirando con esta perspectiva, es poco probable que veamos llevarse a cabo sistemas de alta velocidad en los EE.UU. debido a la gran inversión de capital necesaria para construir tales sistemas. Si algo tiene que quedar claro es que los trenes de alta velocidad en EE.UU. son una solución que tiene que ser vista más adaptada para el futuro económico del país en lugar de su presente y requiere tener en cuenta una tabulación más amplia que incluya los beneficios no monetarios tales como la disminución de la saturación de los modos alternativos o reducir los impactos medioambientales.

Proyectos de tal magnitud no pueden existir, sin duda, sin sus críticos. Muchos están criticando el gasto público adicional, mientras que otros ven la complejidad como insuperables. Existen oortunidades tanto para trenes de alta velocidad como mejoras incrementales de los sistemas existentes a lo largo de los corredores designados. La clave será al menos conseguir un proyecto plenamente aplicado a alta velocidad (a diferencia de aquellos que solo serán capaces de circular a altas velocidades en pequeñas distancias). Una vez que el proyecto esté en servicio comercial, muchas de las preocupaciones expresadas por los críticos, incluyendo las proyecciones de pasajeros y si la alta velocidad es factible en un país donde los coches y el transporte aéreo son dominantes, podrán ser tratadas.

La aplicación de las internacionalmente reconocidas tecnologías ferroviarias de alta velocidad de los países europeos y asiáticos como Japón, Francia o España y el estudio de su experiencia con éste transporte y su viabilidad económica y tecnológica, puede servir a los EE.UU. como el mejor ejemplo para introducir el modo de transporte masivo más sostenible de los existentes en el presente, y así mostrar al mundo que el país que inventó las redes más grandes y más desarrollados de carreteras y transporte aéreo también es capaz de desarrollar el mejor sistema de alta velocidad para poder dar así, un giro a un mundo mejor.

ACKNOWLEDGEMENTS

To my sisters Cristina and Maira, my mom Dolores and my dad Daniel. To my close friends in Reus, Barcelona, Chicago, Austin and many others I have met along the way. To all those I have met at some special place and time in my life; you have made me who I am today. I learned from so many people who continuously encouraged and supported me on my way to finding my own path in life.

The realization of a dream is complete. The adventure that began six years ago has filled this chapter of my life with the most challenging yet rewarding experiences to date. Reflecting upon the choices I made throughout this journey, whether good or bad, I would not change a single one.

What lies ahead now is a world full of new adventures. A world where one finds themselves feeling lost yet excited about the unknown future; a world where one continues to expand their horizons and above all never stops dreaming. If there is one lesson I have learned through over these past few years is that without fear, dreams can come true.

Thank you very much and enjoy!

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1. INTRODUCTION

Around the world, countries are increasingly turning to high-speed trains to meet the growing transportation needs of the 21st century. As countries continue to envision their future, they see modern HSR as an essential component to producing a sound economy and society within their own borders and beyond.

HSR began more than fifty years ago in 1964 when the Tokaido Shinkansen left Tokyo moving at speeds of 130 miles per hour and scheduling 100 million passengers in its first three years of service. Takaido-Shikansen was an unparallel success and became the model for the rail transportation revolution worldwide. In 1981, the TGV began operations in France drawing a billion passengers in twenty years and revolutionizing European travel.

Twelve countries around the world have HSR systems in place with the reach of new high-speed lines ever expanding. Eight more countries including Mexico, Russia and Argentina are currently building or planning to build their own HSR systems. European or Asian countries today would not imagine moving forward in their transportation developments without HSR. These countries are all investing in HSR. Every European country is investing heavily in what woulde a first class HSR system that will connect the entire European community.

Today HSR is faster, quieter and more energy efficient than ever before. Today's 8th Shinkansen trains timidly operate at 185 mph. The French TGV currently operates at 200 mph in regular service. China has recently opened a new train line designed for speeds above 217 mph. HSR technology has not yet reached its limits. An operational German ICE train has reached 252 mph. Test runs on Japan Shinkansen have reached 277 mph and in 2007 an experimental French TGV train reached the world record rail speed at 357 mph. The latest improvements now make it possible to go from downtown London to downtown Paris in 2 hours and 15 minutes and as a result are getting enormous ridership. Clean, electrically powered HSR technology also provides critical environmental dividends. One trip on a French TGV train produces four to five times less carbon emissions than traveling the same distance by air.

In the world's densest urban centers, HSR provide complementary transportation technology that eases congestion on highways. These trains face capacity at increasingly crowded airports by seamlessly integrating high-speed trains with airports and other modes of transit such as subways, light rail, buses and commuter rail. For passengers travel on high-speed trains offers safety and accessibility, rivals times with air travel on trips of up to 500 miles and easily outstrips travel times by automobile and conventional rail service. It also offers passengers a functional transportation alternative while at the same time promoting sustainable patterns in an already existing urbanized society.

The existing transportation system in the U.S. requires significant investments simply to rebuild and maintain critical infrastructure and modernize aging technologies. Meeting the 21st century challenges requires new transportation solutions and HSR is the best for all these concerns as has been demonstrated worldwide.

After decades of relatively modest investment in passenger rail, the U.S. has a dwindling pool of expertise in the field and lacks the means to manufacture capacity. Federal and state governments face a difficult fiscal environment in which to balance critical investment priorities, and many will have to ramp up their program management infrastructure. The country's success in creating a sustainable transportation future depends on how the public and private sectors will overcome these challenges and make the appropriate choices to meet the goals.

In late 2008, the U.S. suffered a major political and historical change. The economic hit that the country suffered imposes new challenges to the introduction of HSR. This report attempts to understand and analyze in depth the current transport situation in the United States. By understanding the particular mobility operations in this country, reviewing past trajectory and comparing with European and Asian countries are the best tools for predicting and encouraging development in America's transportation future.

2. HISTORY OF AMERICAN RAILWAYS

There was a time in the U.S. when railroads crisscrossed the nation and one could find a pair of railroad tracks only a very short distance from their home, and almost every town, large and small, boasted a train station of some type. Sadly, as the 20th century progressed rail began to lose its luster and in the waning days between the 1950s and 1970s enormous amounts of rail heritage was either abandoned or ripped up.

Before introducing the actual situation and future plans of the railroads in America and the role they play compared to other modes of transportation, it is important to understand and analyze their evolution during the past two centuries and the importance that the rail passenger transportation have had on it. The following pages give the reader a summary of this evolution and a broad view of all the changes that both freight and passenger rail transportation has suffered.

2.1 Evolution of the American Railways

The evolution of rail transportation in the U.S. can be conceptualized as a cycle composed phases of introduction and acceptance, rapid growth, maturity and rationalization.

2.1.a <u>Introduction (1830-1860)</u>

The concept of constructing a railroad in the U.S. was first conceived by Colonel John Stevens in 1812. He described his theories in a collection of works called "Documents tending to prove the superior advantages of railways and steam carriages over canal navigation." The earliest railroads constructed were horse drawn cars running on tracks used for transporting freight. The first to be chartered and built was the Granite Railway of Massachusetts, which ran approximately three miles in 1826. The first regular carrier of passengers and freight was the Baltimore and Ohio railroad, completed on February 28, 1827. It was not until Christmas Day, 1830, when the South Carolina Canal and Railroad Company completed the first mechanical passenger train, that the modern railroad industry was born. This industry would have a profound effect on the nation in the coming decades, often determining how an individual lived his life.

From modest beginnings and unsure technology, rail transportation emerged in the 1830s with the construction of numerous local lines in the East, dominantly in the Northeast. During the decade 1830-1840 the total length of completed railroad lines increased from 23 to 2,808 miles. By 1835, dozens of local railroad networks had been put into place. Each one of these tracks went no more than a few miles, but the potential for this mode of transportation was finally being realized. With every passing year, the number of these railway systems grew exponentially. By 1840, 2,808 miles of tracks were laid, but rail transportation was still uncompetitive in view of waterways which had a wider coverage (e.g. Erie Canal, Mississippi). A set of independent feeder rail networks was being established. During the next ten years (1840-1850), more than 6,200 miles of railroad were opened, bringing the total network up to 9021 miles in 1850 (see Figure 1). The most intensive growth during this period was in the Atlantic and Seaboard States. In 1850, a trip from Boston or New York to Chicago was made by rail and lake steamers or by stagecoaches, and required several days. One could travel all the way from Boston to Wilmington, NC, by rail, with several changes of cars and a few ferry trips en route.

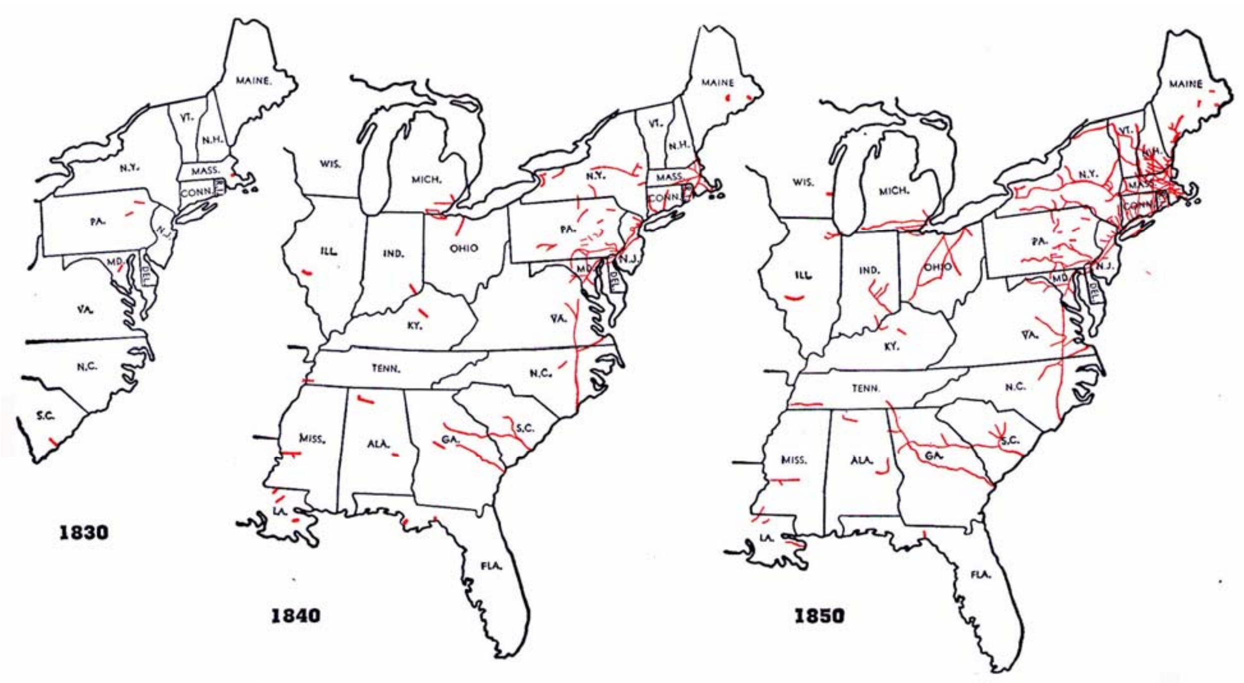

Figure 1. Growth status of American railroads in decades 1830-1850 (Source: [A])

Along with the proliferation of railroads came increased standardization of the field. An ideal locomotive was developed which served as the model for all subsequent trains. Various companies began to cooperate with one another to both maximize profits and minimize expenditures. During the first twenty years of railway development, the population of the U.S. nearly doubled. This interaction of various companies initiated the trend of conglomeration which would continue through the rest of the 19th Century. In 1850, the New York Central Railroad Company was formed by the merging of a dozen small railroads between the Hudson River and Buffalo. Single companies had begun to extend their railway systems outside of the local domain and between 1851 and 1857 the federal government issued land grants to Illinois to construct the Illinois Central railroad. The government set a precedent with this action and fostered the growth of one of the largest companies in the nation **[1]**.

The decade 1850-1860 was a period of rapid railway expansion, characterized by the extension of many short, disjointed lines into important rail routes. This decade marked the beginning of railway development in the region west of the Mississippi River and rail transportation was able to compete more effectively in the resource-rich Midwest. The cost of moving farm produces and manufactured goods over long distances fell by 95% between 1815 and 1860. As shown in Figure 2, by 1860, the American railroads had penetrated westward to the Missouri River and were beginning to make it felt in Iowa, Arkansas, Texas and California. This demonstrated the capacity of the rail system to answer the needs of the national economy and insured a subsequent rapid phase of expansion.

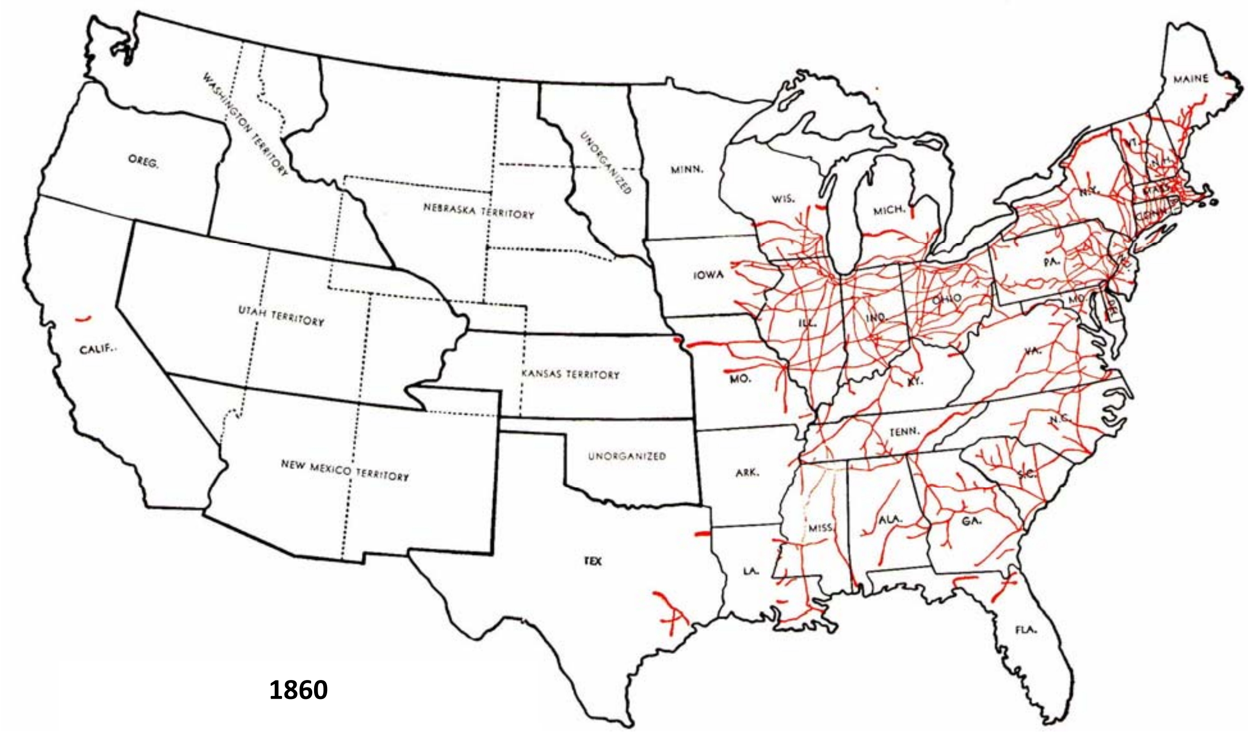

Figure 2. Growth status of American railroads in 1860 (Source: [A])

2.1.b <u>Growth (1860-1910)</u>

As the advantages of rail transportation became widely acknowledged, a massive phase of growth ensued and rail achieved dominance over the road and waterway modes. Although the Civil war between the States (1861-1865) temporally halted railway development felling dramatically the production of new railroads, usage of this mode of transportation increased significantly. Many projects were resumed or initiated soon after the close of that conflict and by the conclusion of the war, the need for an even more diverse extension of railways was extremely apparent.

One priority was the construction of transcontinental line linking the East and the West coasts. Soon after the war, the first transcontinental railroad was constructed (see Figure 3), making it possible for the first time to travel all the way across the country by rail. The Union Pacific Railroad company started building from the east, while the Central Pacific began from the west. The two companies met at Promontory Point, Utah, on May 10, 1869. As they drove the Golden Spike uniting the two tracks, a new age was born. From that point, numerous branches and trunks were constructed leading to an interconnected national rail system. A standard gauge of 1.4351 meters was also agreed upon (in 1860, 23 different gauges were still in use). However, there were many accusations made stating that the rates charged by railroad companies were high and discriminatory, particularly because of the monopoly they had on several parts of the emerging railway system. Slowly, the small railroad companies would die out or be absorbed by large businesses. The nation's network increased from 30,626 miles in 1860 to 52,922 miles in 1870.

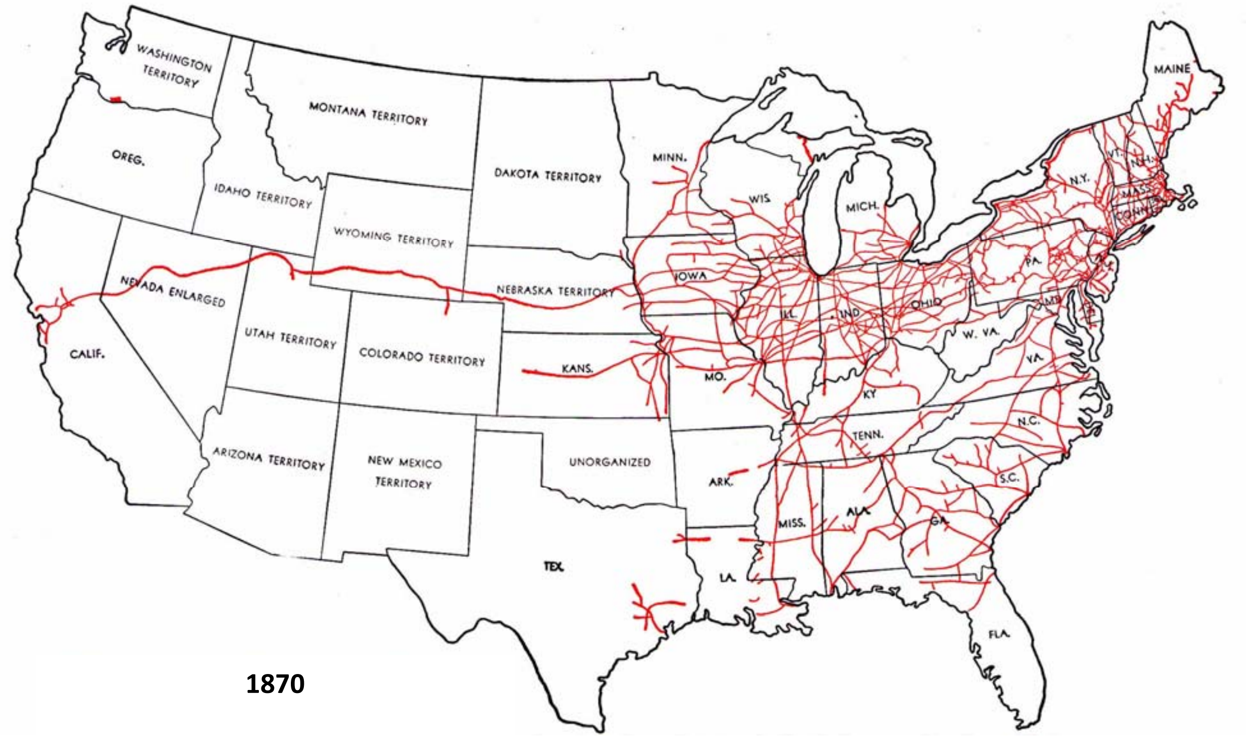

Figure 3. Growth status of American railroads in 1870 (Source: [A])

In 1880, every state and territory was provided with railway transportation. A second line of railroads to the Pacific was nearing completion, and other transcontinental railroads were under construction. Railroad development was exerting a powerful influence upon immigration, agricultural and industrial growth throughout the country. The period from 1880 to 1890 was one of rapid expansion. More than 70,300 miles of new lines were opened in that decade, bringing the total network up to 163,597 miles. By 1890, several trunk line railroads extended to the Pacific (see Figure 4). In addition, labor unions were developed to protect the rights of the workers. As companies grew larger, they began to take over other related fields. Soon, large trusts were formed that controlled many aspects of both the economy and society. In thirty years from 1860 to 1890 every decade brought increased standardization, the total mileage of the region west of the Mississippi River increased from 2,175 to 72,389 miles, and the population of that area increased fourfold. As more and more areas became controlled by the railroad industry, it became apparent that regulation was imperative **[2]**.

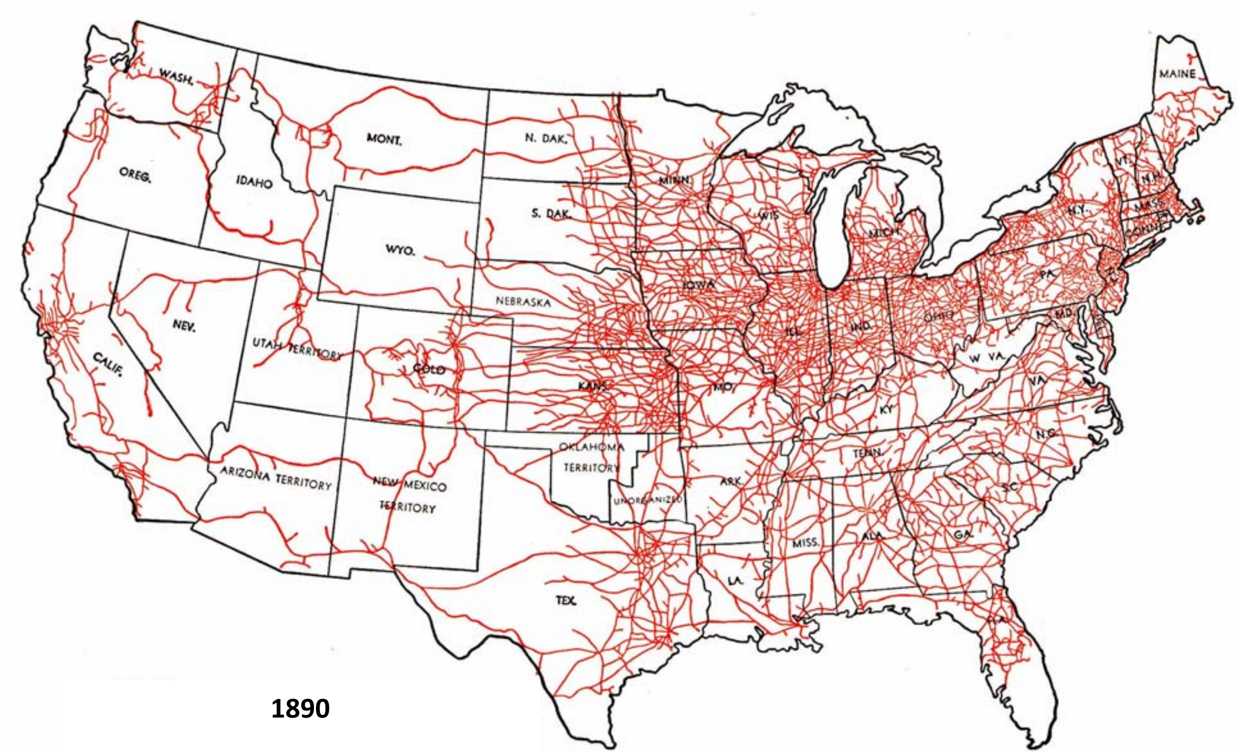

Figure 4. Growth status of American railroads in 1890 (Source: [A])

By the beginning of the 20th century, 193,000 miles of rail were in operation and several lines were being electrified. By 1900, much of the nation's railroad system was in place. The railroad opened the way for the settlement of the West, provided new economic opportunities, stimulated the development of town and communities, and generally tied the country together. There was a time in the U.S. one could find a pair of railroad tracks only a very short distance from their home, and almost every town, large and small, boasted a train station of some type.

2.1.c Maturity (1910-1950)

This period marks the age of rail transportation dominance as of 1930, the 260,000 mile rail network accounted for about 65% of all the freight tonnage carried in the U.S.. Rail technology was standardized and showed little improvements in terms of speed. By 1950, the American Railroads embraced 224,511 miles of tracks (Figure 5). These railroads handled approximately 54% of the commercial passenger and 61% of the freight business of the nation, carried more than 97% of the U.S. mail, and performed nearly all of the commercial express traffic of the nation. During World War II these railroads handled more than 90% of the war freight and 97% of the organized troop movement. However, competition from trucks was starting to being felt, notably for short distances. In addition, heavy regulations from the Interstate Commerce Commission (ICC) created by Congress in 1887 in response to regulate the rates railroads could charge, led to a standard private sector response; lack of investments, increased accidents, reduced punctuality and the bankruptcy of several companies **[3]**.

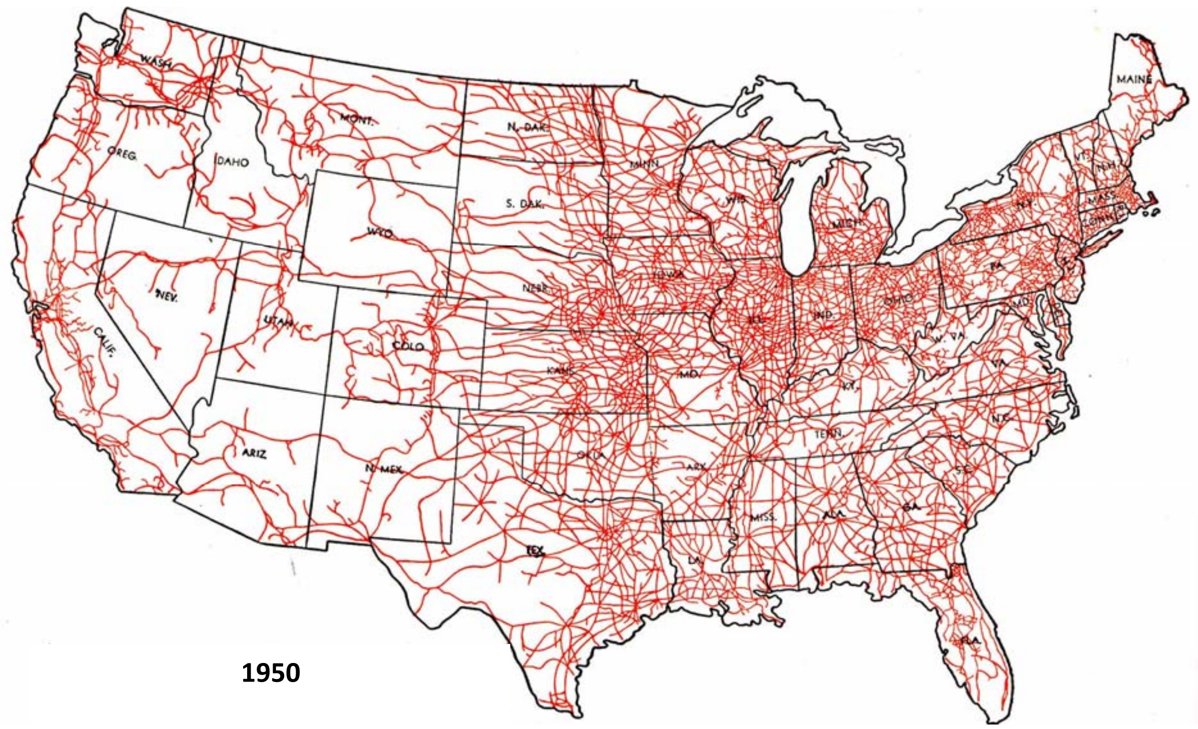

Figure 5. Growth status of American railroads in 1950 (Source: [A])

2.1.d Rationalization (1950-2000)

The post World War II era was one of intense rationalization for rail transportation. By the 1970s, the US railway system was facing serious financial difficulties; several railway companies were going bankrupt, accounting for about 20% of the track mileage and deregulation ensued. In 1980, the Staggers Rail Act enabled rail companies to fix their own rates, service levels, as well as to abandon or sell unprofitable rail segments. Between 1950 and 2000, 123,750 miles of tracks were abandoned which left the rail system with just below 100,000 miles of tracks in 2000, a mileage similar to the mid 1880s. Rail transportation was losing passengers to road and air modes at an accelerated rate, which meant loss of revenue and the abandonment of numerous passengers lines. While there were about 2,000 scheduled passenger trains per day in 1950, this number fell to 200 in the 1990s. As a result, rail transportation became dominantly freight oriented and the development of intermodal transportation in the 1970s justified further rationalization within the rail industry, mainly through mergers. Among the most significant was the Burlington Northern / Santa Fe merger in 1995, followed by the acquisition by Union Pacific of Southern Pacific Railroad in 1996 and the split up of Conrail between Norfolk Southern and CSX in 1999. Freight rates were cut in half and while in 1960 there were 106 rail operators, this figure dropped to 7 in 2005 as shown in Figure 6.

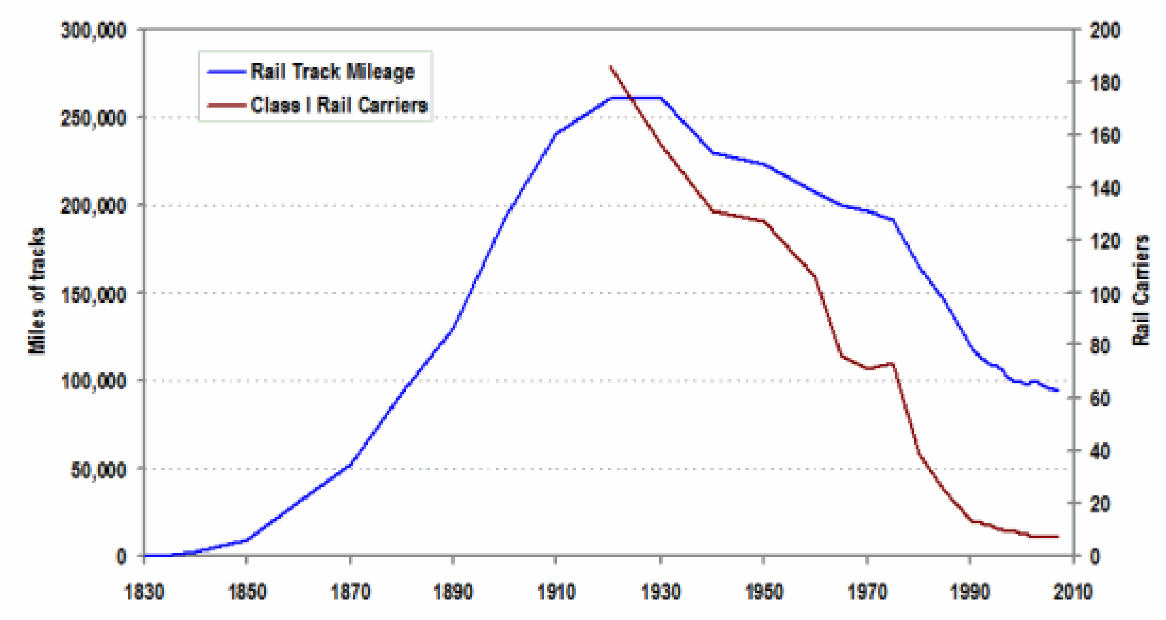

Figure 6. Growth variation of American railroads (made based on Source: [B])

2.1.e Resurgence (2000 - Today)

As of the beginning of the 21st century, rationalization appears to be completed, leaving a more efficient rail system based on high capacity long distance corridors connecting major maritime gateways and inland terminals. These corridors are almost all double-tracked. Additionally, rail freight has faced a surge in demand linked with globalization, a level of deindustrialization of the North American economy, as well as rising energy prices making rail more competitive. The three most important factors behind the recent growth of rail traffic involve a growth of international containerized trade, growing quantities of utility coal being shipped to power plants (namely from the Powder River Basin) and the growth of Mexican trade. A new wave of investments along long distance corridors (double or triple tracking) and intermodal rail terminals has improved the efficiency and the capacity of the system. Prospects about the future of rail transportation appear positive.

2.2 The Rail Passengers Transportation in America: Amtrak

The National Railroad Passenger Corporation, better known as Amtrak, is the U.S. national rail passenger service, providing train transportation between major cities as well as commuter service and delivery of mail and express freight. A private corporation, Amtrak is almost wholly owned by the U.S. DOT.

Congress had created the company on May 1, 1971, with the passage of the Railroad Passenger Service Act. The Act established a private company, incorporated in the District of Columbia. Most of the new company's stock was owned by the DOT, and it was governed by a board of directors made up of the Secretary of Transportation, the head of the corporation, and eleven other members, the majority appointed by the president. During its first year of existence, the corporation was known as Railpax but after it began operations, the nickname was changed to Amtrak, a contraction of the words America and track.

Amtrak was charged with accomplishing three goals described in the Amtrak Source Book as: "To operate rail passenger service on a for-profit basis, to use innovative operating and marketing concepts to fully develop the potential of modern railway passenger service to meet intercity transportation needs and to provide a modern, efficient intercity rail passenger service." Congress authorized grants of $40 million for operations and loan guarantees of $100 million for new equipment. Direct funding was to last only two years, by which time the corporation was to be completely self-supporting. As described previously, by the time Congress created Amtrak, intercity rail passenger service in the U.S. had been in a 20-year decline. Until the 1950s, railroads were the only way to travel long distances. But during that decade, the federal government began financing the interstate highway system, a $41 billion 16-year project, and as jet airplanes were introduced, significantly increased its support for the construction and improvement of airports. Airplanes, personal automobiles, and buses began competing with the country's railroads for long-distance travel. The railroads responded to the competition with new equipment on their prestige long-distance routes, replacing steam locomotives with diesel engines and introducing lightweight stainless steel passenger cars with air-conditioning and double glazed windows. But as the number of passengers continued to drop, the rail companies had little incentive to make major capital investments to upgrade their tracks, signaling, stations and maintenance facilities. By 1958, rail service accounted for just 4% of intercity travel.

The decline in rail passenger service and the deterioration of passenger facilities continued during the 1960s. Most of the loss was on long-distance, intercity travel. Commuter and suburban lines were less affected by airlines and, at least during the 1960s, lost little ridership to buses and private cars. Many of the railroad companies filed applications to get out of the intercity service on most or all of their routes. Among the most critical was the proposal by Penn Central (the merged Pennsylvania Railroad and New York Central Railroad) to eliminate all its passenger service in the Northeast and Midwest. As a federal action, the Railroad Passenger Service Act allowed the railroad companies to transfer their money-losing passenger operations to Amtrak in exchange for either a tax write-off or Amtrak stock. Only three lines, the Denver & Rio Grande Western, the Rock Island and the Southern, did not join Amtrak, opting to continue their own passenger service **[4]**.

The basic network of routes for Amtrak was developed by the DOT with assistance from the Interstate Commerce Commission, the railroad unions, 15 railroad companies, 43 states, some 3,000 members of the public, and numerous U.S. Senators and Representatives. Factors considered in selecting the routes included existing routes, cost, ridership potential, size of the terminal cities (had to have a population of at least one million), and the condition of the tracks and facilities (no funds were allocated for improving these). Between January and May 1971, as the new corporation got itself organized, a major argument developed regarding the company's objective: was it to reintroduce the traditional long-distance routes of the past, such as the Empire Builder, San Francisco Zephyr and Super Chief, or to concentrate on introducing HSR corridors. Those two visions of passenger service in the U.S. would haunt Amtrak for decades.

The creation of Amtrak seemed to generate three conclusions. Some people believed the new entity was really expected to revive intercity rail traffic. The more skeptical seemed to think that this was a last gasp effort and that once the equipment finally gave out, that would be the end of it. Others within the industry and among the passengers saw it as a ruse to eliminate routes in sparsely populated areas while keeping rail service along corridors between major cities in the Northeast and on the West Coast.

During the last half of the 1970s, Congress changed the way they financed Amtrak's capital improvements. Instead of loan guarantees, which had mounted to $900 million between 1971 and 1975, or a designated source of income that was provided for highways and airports, Amtrak began receiving direct capital grants, which had to be requested and approved annually, making it difficult to plan and finance capital investments. Amtrak continued to receive separate annual operating grants. The company's annual revenue during the first decade averaged $252 million, and represented less than 40% of its operating expenditures. The growing deficits led the Carter Administration to push for more efficient operations and cuts in costs. Proposals to eliminate routes as a means of reducing costs generally went nowhere as Senators and Representatives fought to keep trains running in their states, whether the routes were profitable or not. In fact, by 1977, the number of miles in the Amtrak system had grown to 27,000. Finally, under restructuring in 1979, several routes were dropped as the basic network was cut to 24,000 miles **[5]**.

During the 1980s, Amtrak continued to move from supervising to operating the nation's passenger rail system. Amtrak's partnerships with various states improved passenger service in their jurisdictions but the core route and services faced financial cuts as the Reagan Administration convinced Congress to significantly reduce both the operating and capital grants each year. As President Reagan told an audience, "On the New York to Chicago train, it would cost the taxpayer less for the government to pass out free plane tickets." In 1985, Amtrak's supporters argued that shutting down Amtrak completely would result in costly drops in productivity due to traffic jams and crowded airports in the major corridors, especially in the northeast. The prospect of more cars and planes (and the resulting pollution) effectively dampened enthusiasm for eliminating all support for Amtrak, at least for a while.

By the end of the decade, Amtrak operations were bringing in more than $1.2 billion in revenues (see Figure 7). But with operating expenses in fiscal 1989 of nearly $2 billion, it continued to have an operating loss larger than the $554 million operating grant it received from the federal government. In 1994, Congress and the Clinton Administration demanded that Amtrak operations become self-sufficient by 2002. To accomplish this, the company adopted a strategic and business plan for the period of 1995 to 2000. As part of the plan, Amtrak decentralized itself into three business units to increase accountability and responsiveness: the Northeast Corridor (NEC), covering services from Virginia to New England; Amtrak West, which operated state-supported corridor trains and the long-distance Coast Starlight on the West Coast; and Amtrak Intercity, responsible for most of the long-distance routes as well as corridor trains in the Midwest. The company also began raising fares, cutting routes and service, and implementing cost reduction programs for its operations. However, Amtrak needed new rolling stock to replace old equipment, to achieve better travel times, and to meet the requests from states for new intrastate rail services.

Through 1990, Amtrak had spent $1.6 billion for cars and locomotives and the capital investment continued during the decade with the delivery of new diesel locomotives, 195 bi-level Superliners, and in 1996, 50 Viewliners, the first single-level sleeping cars made in the U.S. in 40 years. In California, 14 new dual-level dining cars were introduced on the state-supported routes, and in Washington, three pendular "tilt" Talgo trains were ordered by Amtrak and the Washington DOT for delivery in 1998. Trains able to travel 150 mph were added to service the NEC beginning in 1999. Although revenues increased to $1.6 billion in fiscal year 1996, debt and capital lease obligations were almost $1 billion. By 1997, Amtrak was in danger of going bankrupt. Congress debated the company's request to designate one-half cent of the Interstate Highway Trust for capital expenditures, but instead passed a tax rebate package of $2.3 billion for Amtrak capital spending over two years and adopted a package of reforms changing various labor requirements, allowing Amtrak to alter the basic system of routes inherited in 1971, setting a cap on liability costs, and establishing a new Reform Board **[6]**. Funding for the DOT for fiscal year 1998 included $344 million for Amtrak operations and $250 million for the NEC capital. It also included $23 billion for highways, $9 billion for aviation, and $4 billion for transit.

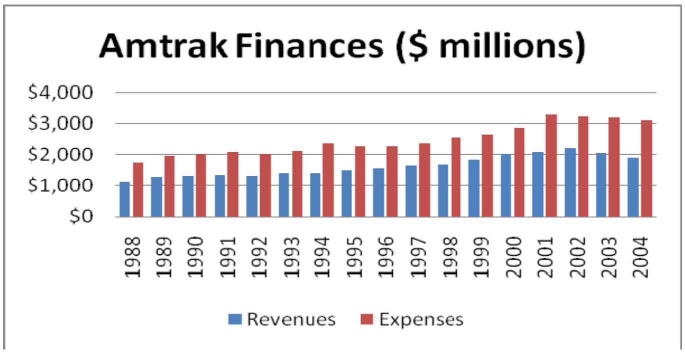

Figure 7. Amtrak revenues and expenses in period 1988-2004 (made based on Source: [C])

Despite the shakeup at the top and numerous skeptics, Amtrak survived. The company continued its efforts to improve service, spending $26.6 million to overhaul 212 passenger cars. Buttressed by the Taxpayer Relief Act of 1997 Amtrak launched a $360 million capital improvement program. They spent $100 million for eight new five-car train sets for San Diego service, purchased eight locomotives, 64 carriers, 43 coaches, several improved refrigerator cars, and numerous expensive equipment updates. New lines and improved travel times resulted in several cities. In December 1998 Amtrak agreed to purchase 44 RoadRailer Mailvans. Acting President and CEO George D. Warrington cited increasing rail revenues which had been rising 10% each year as reason for the investment, which he stated could only bolster their bottom line. Warrington continued to assemble a new management team, envisioning an Amtrak that featured HSR corridors across the country and high-quality service. Statistics had confirmed that Amtrak continued to improve between 1998 and 1999, the percentage of riders was the highest it had been in a decade, on-time arrival was the highest it had been in 13 years (Figure 8), and passenger revenues had topped $1 billion for the first time.

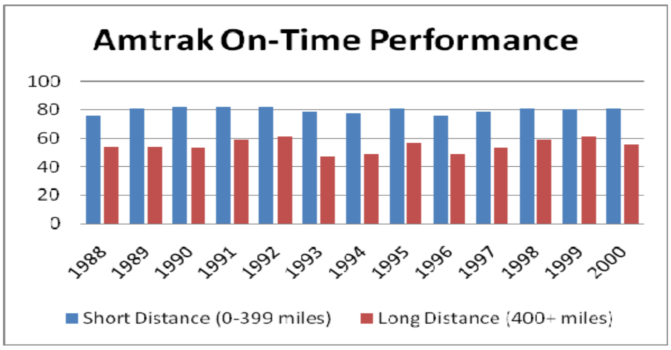

Figure 8. Amtrak short and long distance on-time performance (made based on Source: [C])

In March 2000 Amtrak introduced the Acela Regional passenger service, creating the long-awaited electrification of the NEC linking Boston, New York, and Washington, D.C. The result was a reduction in travel time from Boston and New York by up to 90 minutes. Further improvements were unveiled in November 2000, after months of delay. The Acela Express, the nation's first HSR system began travelling the Northwest Corridor's tracks at up to 150 mph, reducing a Boston to New York trip to 3 hours and 15 minutes, a New York to Washington, D.C. trip to 2 hours and 28 minutes. The Acela beat its projected profits by 12% in the first quarter of 2001 and launched Amtrak into its most profitable year yet **[7]**. The success prompted Congress to reconsider a controversial bill to allow Amtrak to issue bonds to raise $12 million dollars for the HSR system.

Today, federal government, states and local decision makers have had a renewed interest in looking at how HSR might fit into the American national transportation system and address increasing mobility constraints on the nation’s highways and at airports due to congestion. Although the current economic downturn has recently reduced the level of highway and air travel, projections show that intercity travel will grow again and that existing transportation capacity limitations will constrain mobility. The DOT estimates that several intercity highways linking major urban markets will experience significant congestion by 2035. Capacity limitations will constrain air traffic at 14 airports in 8 metropolitan areas, even if planned capacity improvements are carried out through 2025. In addition, the dependence of growing highway and air travel on fossil fuels raises significant environmental concerns regarding greenhouse gas emissions. As a result, transportation decision makers are exploring options that not only expand transportation capacity and relieve increasing congestion but also minimize the deleterious environmental impacts of increasing highway and air travel. The average intercity passenger train can produce significantly less emissions than other transportation modes. Amtrak has seen nearly a 20% increase in riders in the last 2 years, in part because of service enhancements in some intercity corridors have improved overall travel time and reliability, making the train more competitive with highway and air travel. Still, Amtrak does not offer service in many heavily traveled intercity corridors. Moreover, Amtrak's service, shown in Figure 9, continues to have slow average speeds relative to other transport modes, and experiences significant delays, often resulting from sharing track with commuter and freight rail.

Figure 9. Actual Amtrak routes (Source: [D])

Proposals for investment in HSR in the U.S. have existed for decades. However, corridor service that exceeds Amtrak's predominant top speed of 79 mph currently only exists on Amtrak's NEC between Boston, MA, and Washington, D.C., and in a few other corridors (including New York City, NY, to Albany, NY; Philadelphia, PA, to Harrisburg, PA; and Los Angeles, CA, to San Diego, CA) and on a segment of track between Chicago, IL, and Detroit, MI. By contrast, countries in Europe and Asia have developed extensive rail systems with top speeds exceeding 150 and even 200 mph, which have attracted a relatively high number of riders compared with other transportation modes.

Throughout history, Amtrak has been funded at a rate of tenths of times lower than the rate at which Congress has funded highways and aviation, and continued to own little of its own track. Still, with the new HSR, rising passenger rates and improved funding, the future looked if not rosy, then far more promising than it had in many years.

3. MODAL SPLIT OF TRANSPORTATION IN THE U.S.

Transportation in America contributes 11% of the Nation's gross domestic product, amounting to approximately $950 billion. Transportation accounts for 19% of spending by the average household in America (as much as for food and health care combined) and is second only to spending on housing. The US transportation system carries over 4.7 trillion passenger miles of travel and 3.7 trillion ton miles of domestic freight generated by about 305 million people. Rail and maritime transportation each account for over 11% of the tonnage carried. The transportation system comprises more than 4 million miles of public roads and 2 million miles of oil and natural gas pipelines. There are networks consisting of 120,000 miles of major railroads, over 25,000 miles of commercially navigable waterways, and over 5,000 public-use airports. This vast system also includes over 500 major urban public transit operators and more than 300 ports on the coasts, Great Lakes, and inland waterways.

After 60 years and more than $1.8 trillion of investment, the U.S. has developed one of the world's most advanced highway and aviation systems. Yet these systems face mounting congestion and rising environmental costs. Moreover, the U.S.' current transportation system consumes 70% of the oil demand of the country and contributes 28% of greenhouse gas emissions.

While it was once the preeminent mode of travel, intercity passenger train travel in America has played a relatively minor role in the second half of the 20th century. With the expansion of the highway and aviation systems, total intercity travel in the U.S., has grown dramatically. Much of this growth in intercity travel has been fueled by an aggressive public investment strategy. For six decades, federal transportation policies have focused most intercity transportation investment in the highway and aviation systems. Passenger rail has represented less than 3% of the rapidly growing Federal investment in intercity transportation, and until 2009, that share has been shrinking. The existing infrastructure is insufficient to handle the future passenger and freight mobility demands. A possible solution to solve the problem and improve the transportation in America would be to build an efficient, HSR network of 100 to 600 mile intercity corridors, as one element of a modernized transportation system.

To understand the HSR proposal in the U.S. and its viability, it is necessary to first start analyzing and understanding the paper of the different modes of transportation in America and comparing them internationally with other countries where the HSR has been established during the past decades. The HSR infrastructures depend on many geographical, demographic, cultural and economical factors that are very different in every country and continent and that determine the efficiency and viability of all the HSR projects.

3.1 Demography

The U.S. has a total population of 305 million with a very urbanized nation, with 81% of the population residing in cities and suburbs as shown in Figure 10 (in 2005 the worldwide urban rate was 49%) and a population density of 86 habitants/mile^2. The mean population center of the country has consistently shifted westward and southward (see Figure 11), with California and Texas currently the most populated states.

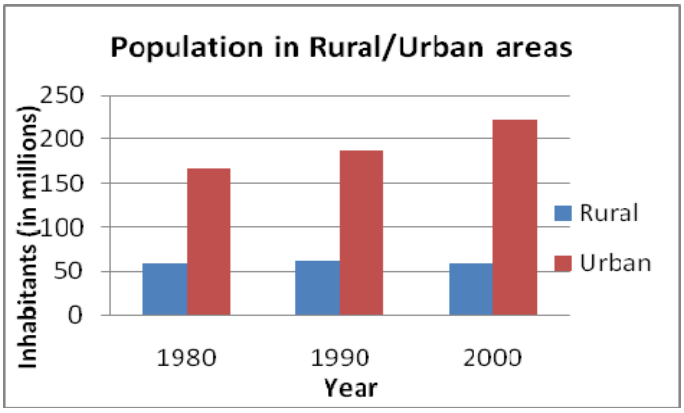

Figure 10. American Population in Rural/Urban areas (made based on Source: [E])

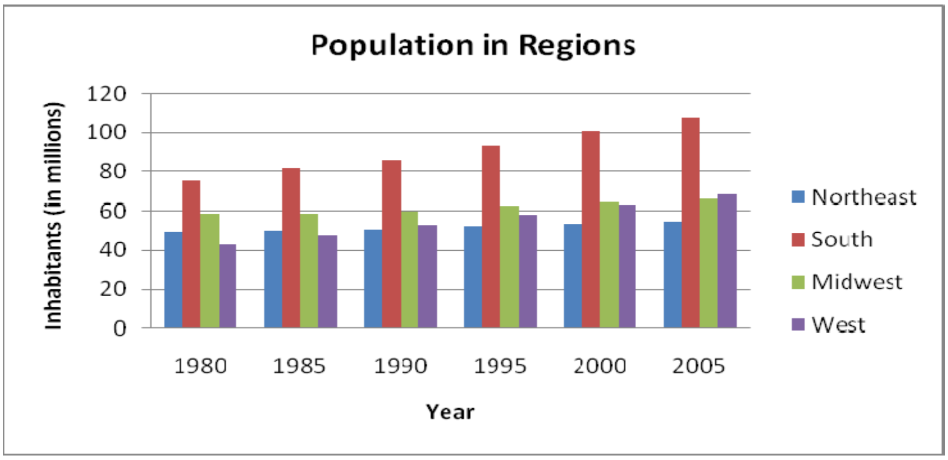

Figure 11. American Population by Regions (made based on Source: [E])

The U.S. doesn't have a very high population density compared to countries with planning or having HSR projects (see Appendix 1, Source: **[F]**). Important HSR countries like Japan have ten times more population density and in Europe, countries like France or Spain have three times more.

Although this could be seen as an inconvenience when trying to analyze this important factor, the population of some states is very low because of the geographic and climatic conditions (Figure 12). The large extension of those states with their low levels of population, decrease the average of population density of the country (see Appendix 2; Source: **[G]**). See also Appendix 3 (Source: **[H]**) for the states Geography.

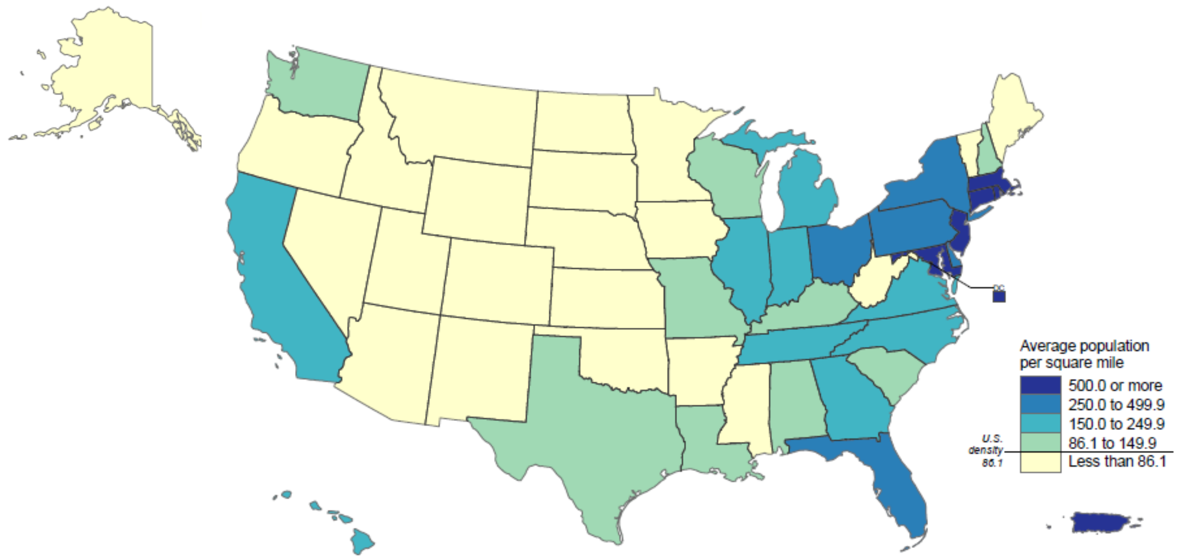

Figure 12. Population Density by States (Source: [E])

3.2 Passenger Transportation

With any transportation decision, speed to destination is an important factor in choosing any particular type of infrastructure, and distance remains a significant factor in passengers' modal choice (see Figure 13). However, in a motorized society such as the U.S., the automobile plays a significant role for short distances and, moreover this has a lot to do with the physical setting which tends not to be favoring walking.

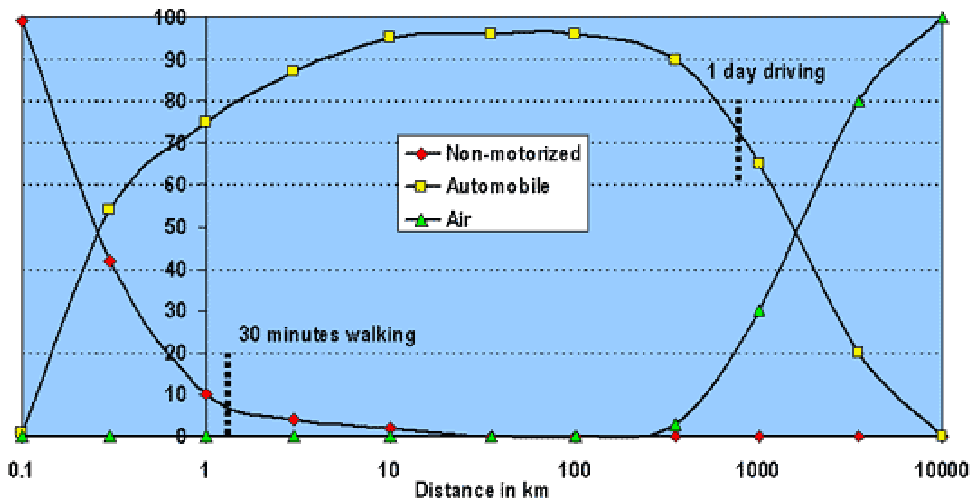

Figure 13. Modal Split in the U.S. by Passenger Travel Distance, 1995 (made based on Source: [8])

All this factors, including the government support, has brought the country to use the road and air transport as the main modes of passenger transportation.

In comparison to other modes of transportation and other countries in the world, the U.S. relies much more heavily on its roads both for commercial and personal transit (see Figure 14). There are more than 2,615,870 miles of paved roads and 1,401,791 miles of unpaved roads. The network is composed by the Interstate system, the US Highway system, the individual networks of State Highways, and other jurisdictional highways such as those of counties, municipal streets, or federal agencies.

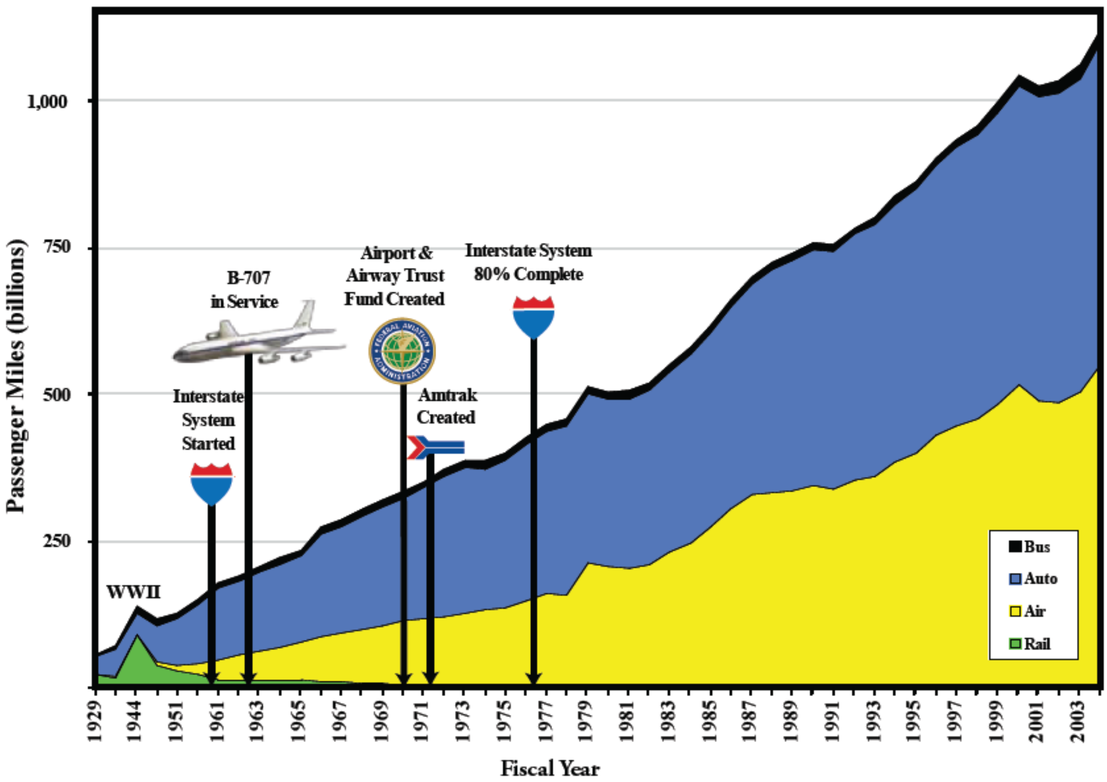

Figure 14. U.S. Intercity Travel Trends by Modal Share, 1929-2004 (Source: [9])

Road development in the U.S. accelerated in the first half of the 20th century. By the 1920s, the first transcontinental highway, the Lincoln Highway, spanned 3,389 miles between New York and San Francisco. The post World War II era represented a period of rapid expansion of road transportation networks worldwide with the most remarkable achievement in the U.S. with the American Interstate highway system initiated in 1956. Its strategic purpose was to provide a national road system servicing the American economy and also able to support troop movements and act as air strips in case of an emergency.

From its inception, the Interstate highway system expanded substantially, but at a declining rate as the system reached its planned size of 46,000 miles (Figure 15). About 35,000 miles was built from the 1950s to the 1970s, but between 1975 and 2006 only 9,000 miles were added to the system, underlining growing construction costs and diminishing returns. By 1991, the system was considered completed, almost to the initial plan, with a total cost of about $129 billion. Between 1954 and 2001, $370 billion were invested by the federal government in the construction and the maintenance of the system. However, the Interstate is facing diminishing returns due to high construction and maintenance costs, which is forcing many state governments to consider privatization of several highway segments. Construction costs went from $4 million per mile in 1959 to $20 million in 1979. Still, the system has returned more than $6 in economic productivity for each dollar it cost, placing it at the core of American economic productivity in the second part of the 20th century. Overall, about 46,837 miles of four-lane and six-lane highways were constructed, linking all major American cities, making it both the largest expressway system in the world and the largest public works project in US history.

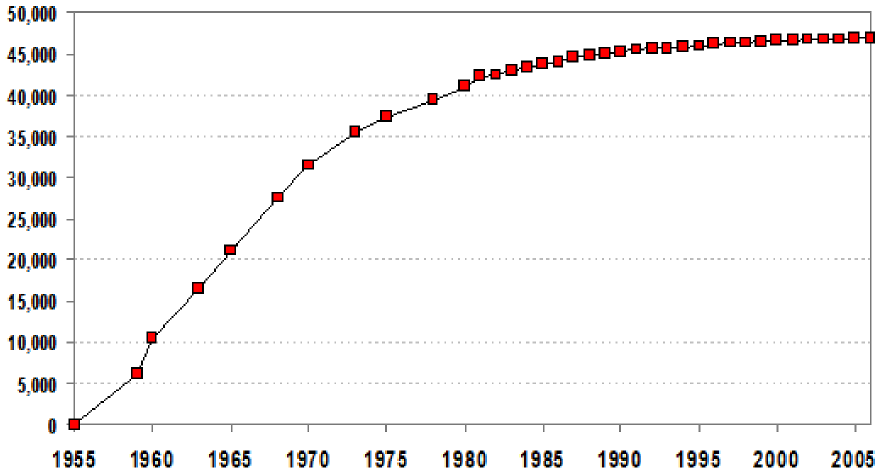

Figure 15. Length in miles of the Interstate Highway System, 1959-2006 (Source: [I])

An interesting ratio that shows the dimensions of the American road system compared with the population and extension of the country, it is the following Figure 16. The two density measures portrayed reveal different geographical settings and levels of motorization of some different countries in the World. Although the U.S. and Canada have low levels of road density per square kilometers comparatively to Japan and Western European countries, they are significantly committed to road transportation. This commitment is reflected in the availability of roads per capita (km per million people) where significantly higher figures are observed.

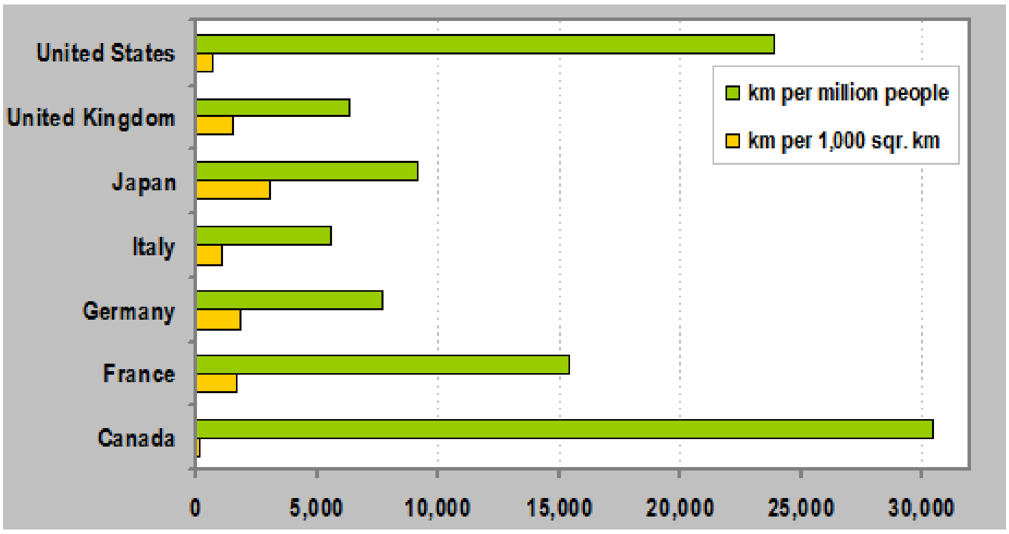

Figure 16. Road Transport Density Measures, G7 Countries, 1996 (Source: [J])

In terms of car density in the population among U.S., Japan and the average of the 27 countries in Europe, there is less than one car for every two inhabitants in the EU-27 compared with almost one car for every inhabitant in the U.S.. From 1990 to 2005, the number of cars per 1 000 inhabitants in the EU-27 grew at an average annual rate of 1.9 %, exceeding the rate of 1.6 % in Japan over that period, and more especially the rate of growth of 0.4 % in the USA (see Figure 17). It is interesting to note that, in Japan, the motorization rate in fact remained constant after the year 2000.

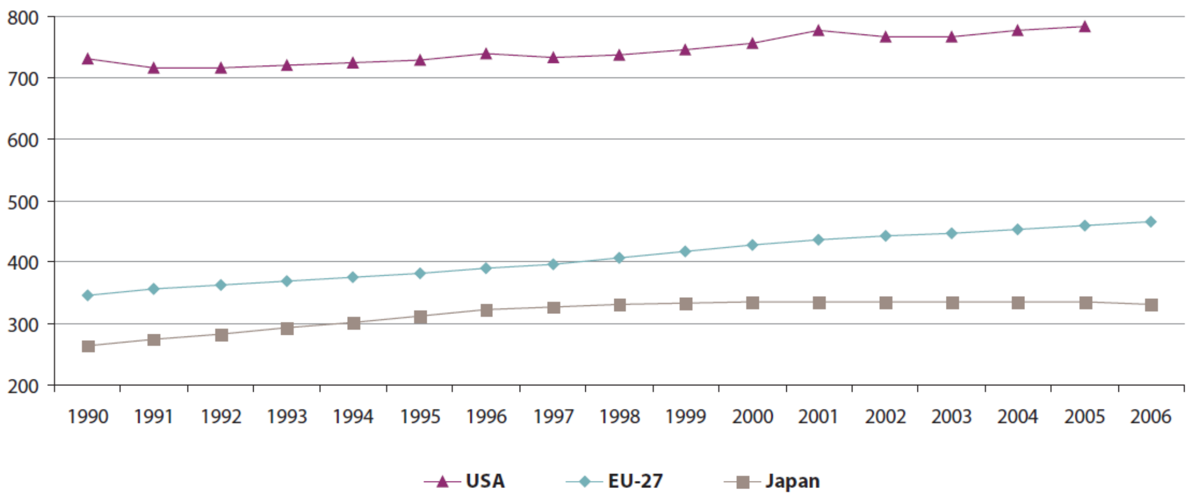

Figure17. Number of passenger cars per 1000 inhabitants, EU-27 and U.S. during period 1990-2006 (Source: [10])

Comparing the passenger transportation in the U.S. with countries with existing HSR lines, it is been observed a huge difference on the modes of transportation used. U.S. is the country with a major use of the car and less use of the railway (see Figure 18).

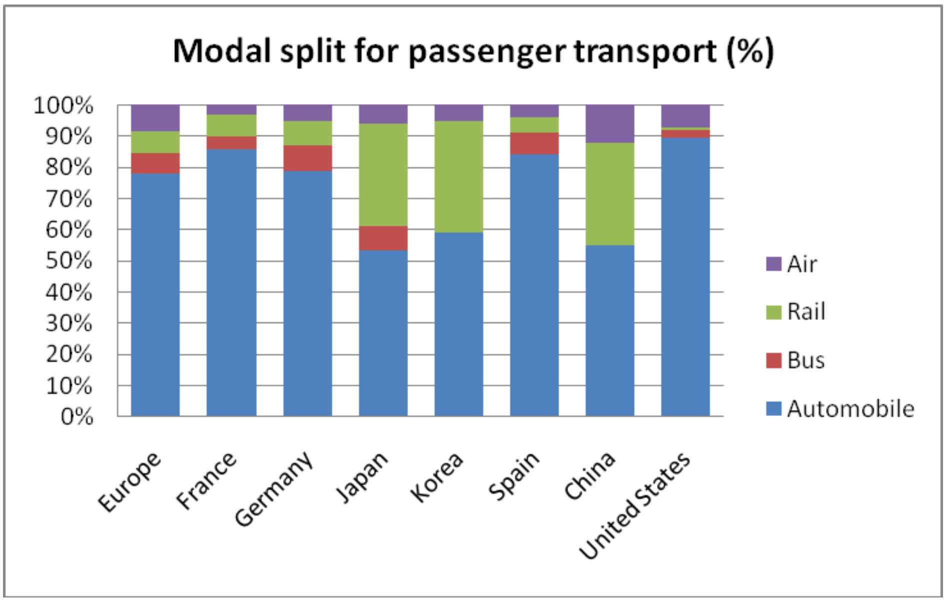

Figure 18. Modal split for passenger transport in selected countries in 2007 (made based on Source: [11])

Analizing Figure 19, the long-distance travel in the U.S. (roundtrips at least 50 miles away), 66% of the trips are done within 300 miles and the use of the air flights is higher than the car when distances are above 750 miles (see Figure 20). Taking into account that the road system has arrived to its completion and that the HSR is time competitive with air and auto for travel markets in the approximate range of 100 to 500 miles (160 to 800 kilometers), it is interesting to see the possible positive introduction of the HSR in America.

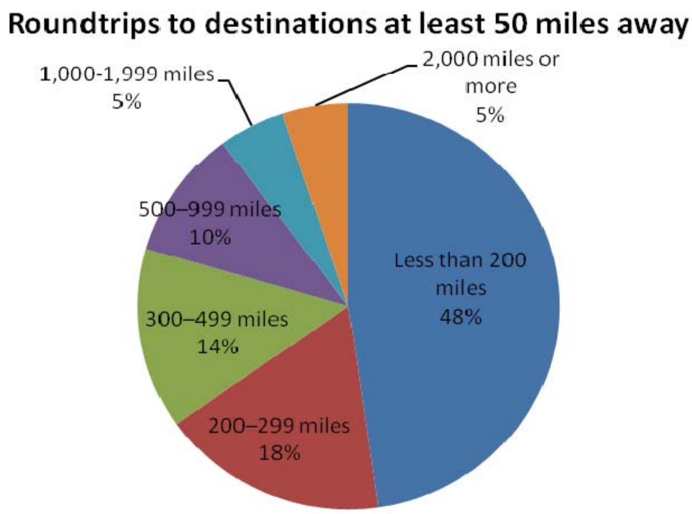

Figure 19. Long-Distance Travel in the U.S. (Source: [J])

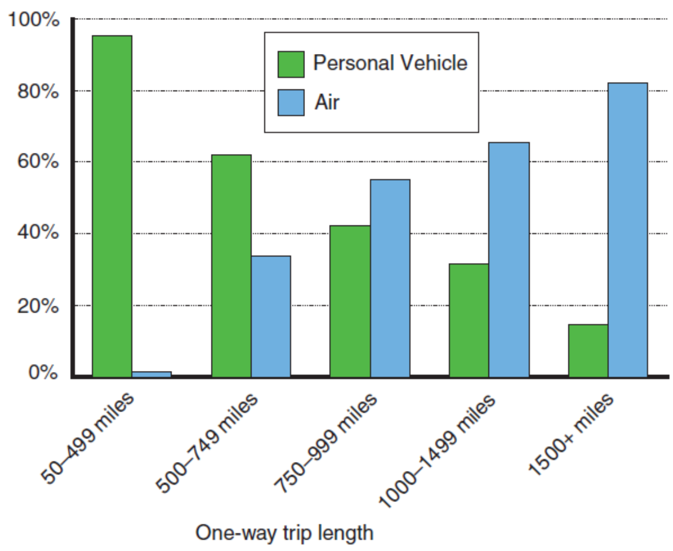

Figure 20. Mode Share for Personal vehicle and Air at Various Trip Lengths in 2001(Source: [12])

When trying to understand the introduction of HSR in America it is important to take into acount the air transportation system. Commercial air transportation is a young industry which has made rapid progress (more than any other mean of transportation has made before). The growing pervasiveness of air travel can be seen by the increasing numbers of people who have flown on a commercial jet: less than 50% in 1975 compared with more than 80% today. In terms of passengers, 17 of the world's 30 busiest airports in 2004 were in the US, including the world's busiest, Hartsfield-Jackson Atlanta International Airport.

The new era of commercial jet transportation in the U.S. was introduced in October 1958. Pan American World Airways inaugurated regular scheduled service from New York City to Paris, and later the National Airlines inaugurated the first domestic jet service with leased Pan American jets. The jet era entered a second generation in February 1970 when Pan American World Airways introduced Boeing 747 service between New York and London. The 747 is capable of carrying 420 passengers and the Boeing 707, which Pan American flew in 1958, carried 150 passengers.

The economic effects of the present air transportation in U.S. have been a shrinkage of distance in terms of time, an expanded jet transport capacity in comparison to propeller-driven aircrafts, an increase in the number of people using air transportation for business and pleasure and a shift of traffic volume from surface to air. Recession and inflation, the latter highlighted by soaring fuel costs, combined in 1980 to produce an operating loss and a sharp decline in passenger traffic for the nation’s major scheduled airlines. The weakness in the economies of the world over the past several years has caused the air carrier industries to experience its worst financial years in its history. Two of the oldest and greatest names in the industry, Eastern Airlines and Pan American, ceased operating years ago and others are facing bankruptcy. Althought the industry’s overall financial fortunes have improved, not all carriers have shared equally in the financial turnaround. There have been eleven bankruptcies since deregulation began in 1978 and more would have occurred except that failing carriers merged with or were taken over by other carriers.

To a certain extent, the airline industry is a victim of its own success. Commercial aviation has growth faster than airports and airway systems in which it operates giving rise to many of the industry's current problems. Twenty-one airports in US are labeled seriously congested by the Federal Aviation Administration. The agency warns that another twenty may qualify for this dubious distinction if there are no additions to system capacity. According to agency forecasts, large hub airports, which account for virtually all this congestion, can except a 28% increase in air traffic and a 70% increase in passenger enplanements by the year 2020. Without offsetting increases in systems capacity and efficiency, which will not be easly achieved, the system will be under even more pressure in the future.

In Europe, the air transportation system is not at the level of congestion as it is in the United States. Next Figure 21 shows annual passenger traffic growth in the US and Europe between 1999 and 2008.

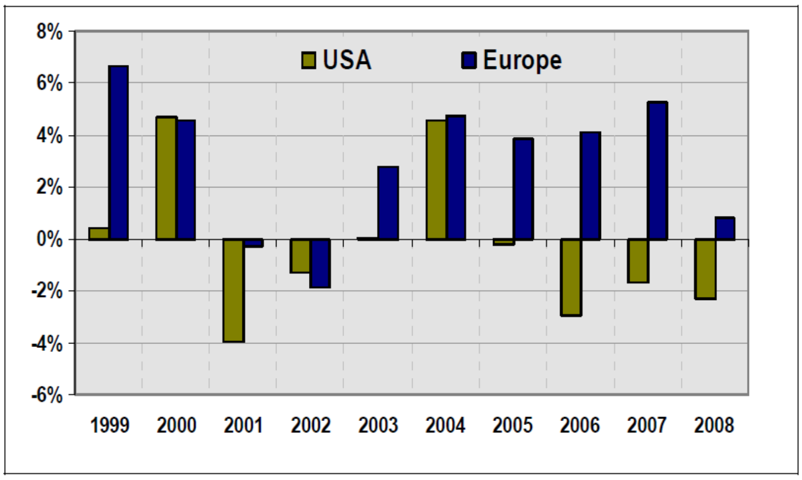

Figure 21. Annual Air Traffic Growth in the U.S. and in Europe, 1999-2008 (Source:[13])

Until 2004, growth rates evolved in similar ways on both sides of the Atlantic, but there has been a notable difference since then. In Europe, air traffic continued to grow at around 4% annually while it decreased significantly in the US.

3.3 Freight Transport

Four eras describe the evolution of the U.S.' freight system. Three are characterized by the development and maturation of a single transportation technology while the fourth is characterized by the emergence of information and communication technologies to manage and utilize all modes of transportation.

The colonial economies of the 18th century were built on water transport (“Sail Era”). At the time of the American Revolution, it cost as much to move a ton of goods 30 miles inland as it did to move it across the Atlantic. Two out of three settlers lived within 50 miles of the Atlantic coast. Coastal and Atlantic trade dominated the freight system.

The introduction of rail technology (“Rail Era”) in the mid-19th century freed businesses and industries from the need to be located near seas, rivers, and canal ports. Within a matter of decades, railroads opened up much of the interior of the country. East–west rail routes were built to follow development of the Midwest, and after the Civil War, to solidify political and military control of the West. But north–south rail routes were slow to develop because the railroads could not compete effectively with water transport for coastal trade. Dense urban centers grew at major inland rail hubs and in coastal cities that benefited from the new mode of transportation. Domestic inland trade dominated the freight system.

The development of truck and highway technologies (“Truck Era”) in the early 20th century freed businesses and industries again, this time from the need to be located near rail lines and terminals. An east–west and north–south interstate highway grid was built to connect cities and regional economies. Production and consumption centers migrated outward from city centers, taking advantage of inexpensive land made newly accessible by the trucking and highway systems. Long-haul trucking captured a large share of east–west freight traffic from railroads and much of the north–south freight traffic from coastal steamers and river barges. While rail and water continued to serve some traditional markets, trucks were the only way to serve the new suburban and ex-urban markets, and trucking became the dominant mode of freight transportation.

The global economy of the 21st century is being built on information, telecommunications, and low-cost, long-haul transport by water, rail and air (“Integration and Information Era”). Containerization (first introduced in the 1950s), efficiently linked trucks, double-stack trains, and containerships, significantly reducing transport costs, cargo pilferage and damage. The parallel development of information and communication technologies made it possible to manage global freight flows that were reliable, visible, reasonably secure, and cost-effective **[14]**.

During the last 50 years, the Class I rail and trucks have been established as the most important modes of freight transportation in the U.S. (see Figure 22). Unlike passenger transportation, the freight-rail system is an important part of the America’s freight transportation system and is critical to the economy. Freight rail carries 16% of the U.S. freight by tonnage, accounting for 28% of total ton-miles, 40% of intercity ton-miles, and 6% of freight value.

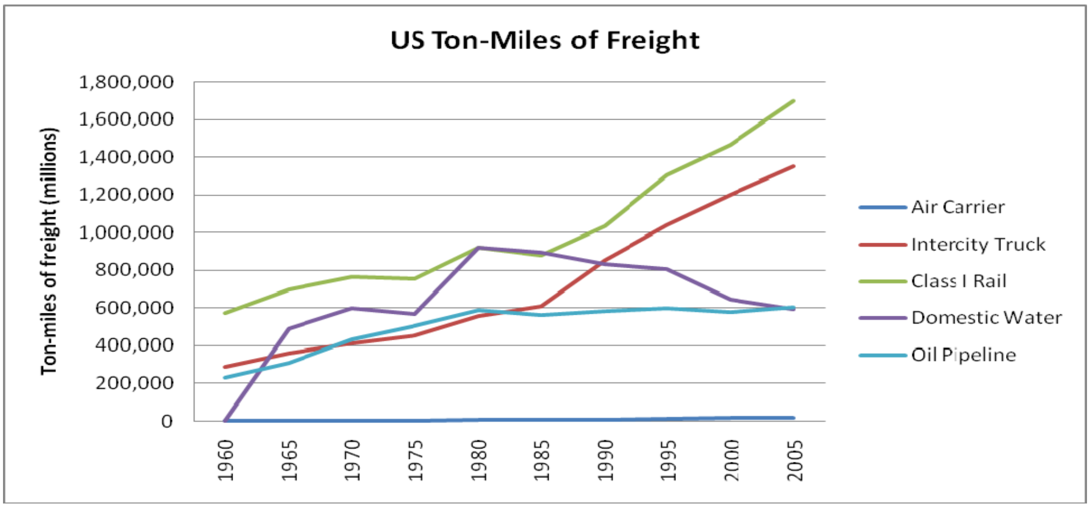

Figure 22. Ton-Miles of Freight in the U.S., 1960-2005 (made based on Source: [J])

Comparing these numbers with those in Europe and Japan, modal split reflects different geographical conditions in which transport systems operate (Figure 23). While within the European Union and in Japan road and coastal shipping account for the great majority of tons-km, rail dominates in the U.S.. The continentality and the fragmentation of the American economy in specialized regions are prone to long distance rail shipments as well as reliance on pipelines to supply large consumption of fossil fuels, namely petroleum and natural gas. In the case of the EU and Japan, the high densities, relatively short distances involved, and the maritime exposure favor trucking and usage of coastal shipping.

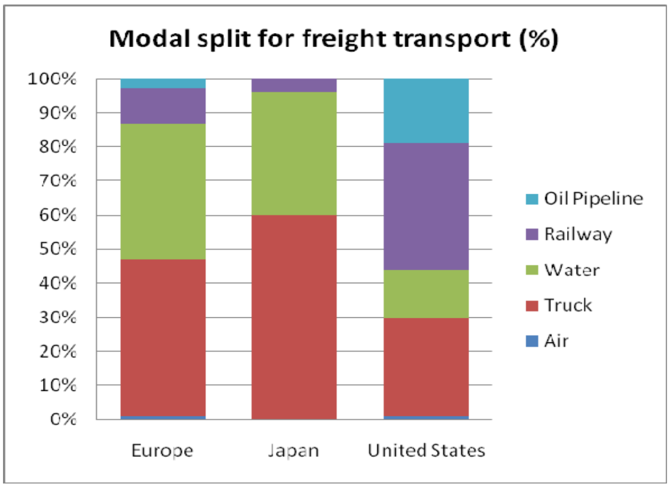

Figure 23. Modal Split in the EU, U.S. and Japan, 2006 (in % of tons-miles) (made based on Source: [10])

Because of its cost (Figure 24) and limitations, the air freight industry remains a mix of dedicated large companies (such as FedEx), small-time operators (such as OCS Air Freight), and passenger airlines (such as United Airlines) that operate cargo divisions, which have a minor impact on the global transport of goods in the country.

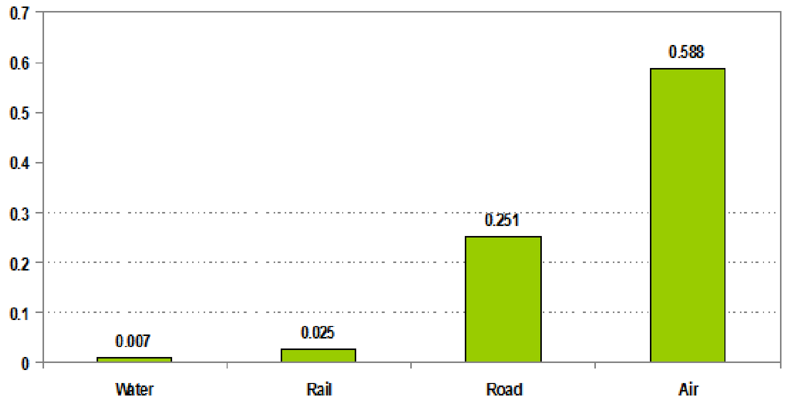

Figure 24. Freight Transport Costs in US $ Cents per Ton-Mile, 1998 (made based on Source: [15])

3.4 Actual status of the Transportation in the United States

The combination of economic prosperity and a population that just passed 300 million have produced a high demand for personal and freight mobility in the U.S.. Congestion is one of the single largest threats to American economic prosperity and lifestyle. Whether it takes the form of trucks stalled in traffic, cargo stuck at overwhelmed seaports, or airplanes circling over crowded airports, congestion is costing America an estimated $200 billion a year.

Each year, Americans lose 3.7 billion hours and 2.3 billion gallons of fuel sitting in traffic jams and waste $9.4 billion as a result of airline delays. Congestion is not a fact of life. It is not a scientific mystery, nor is it an uncontrollable force. Congestion results from poor policy choices and a failure to separate solutions that are effective from those that are not.

The U.S. Administration's objective must be to reduce congestion and not simply to slow its increase. Congestion is not an insurmountable problem. However, solutions will require a smarter approach to capacity expansion and improved productivity of existing transportation assets. Reducing congestion is about making the right investments in transportation capital stock. The public sector has limited funds and the needs are great, despite record funding for surface transportation in recent decades. The federal government's most important role is to establish mechanisms to ensure that the right investments are made. Today, the HSR in the U.S. has a great opportunity to be introduced as the perfect alternative to solve the overload of existing infrastructures.

4. APPROACH TO THE HSR IN THE U.S.

Since the 1960s, HSR has held the promise of fast, convenient, and environmentally sound travel for distances between 40 and 600 miles around the world. Japan was the first to deploy HSR in 1964 when the Shinkansen bullet train began service between Tokyo and Osaka, with top speeds of 270 km/h (169 mph). This was followed in 1982 by France's Train à Grande Vitesse (TGV), linking Paris and Lyon at speeds of 300 km/h (188 mph), and later by Germany's Intercity Express (ICE) that also operates at speeds up to 300 km/h (188 mph). South Korea recently began HSR service and Taiwan is expected to follow shortly, the former using French technology and the latter using Japanese bullet train technology **[16]**.

The international definition of HSR is considered as new lines with a speed of at least 155 mph (250 km/h) and existing lines with a speed of around 125 mph (200 km/h) **[F].** In the U.S., high speed ground transportation is been defined by the FRA as rail or Maglev systems capable of speeds of 90 mph (145 km/h) or more **[K]**. These systems have been classified in three different forms, and described as follows:

- **Incremental HSR (INCREMENTAL HSR):** Consists on making incremental improvements to the existing conventional tracks, signaling systems, grade crossing and existing technology and purchase modern trains that could permit speeds between 90 and 150 mph on existing ROW. In the U.S., most projects aim for 110 mph (177 km/h) using electrified or non-electrified systems.

- **New high-speed rail (New HSR):** Build completely new rail infrastructures to support very high-speed operations of 200 mph or more. This requires new ROW and imported technologies currently used in Asia or Europe that typically allow speeds greater than 200 mph.

- **Magnetic levitation (Maglev):** Build Maglev systems that could permit speeds around 300 mph by doing away with steel-wheel-on-steel-rail.

4.1 Efforts to develop HSR in the U.S.

The U.S. experience with HSR has differed greatly from that in Asia and Europe. American Congress first authorized studies aimed at deploying HSR with the HSGTA of 1965, but to date there is only one example of such systems in the U.S. (the NEC) and whether these systems are truly high-speed is debatable. Despite numerous efforts by States and the federal government, nearly all U.S. HSR projects have failed to progress significantly, and none has come close to matching the performance levels of Asian and European systems.

Unlike its European and Asian counterparts, which made HSR a national priority once it became clear that railroads were either in or potentially headed for decline, the U.S. government has been reluctant to develop such projects. The only intercity rail effort moved forward by the federal government beyond pilot studies and technological research has been Amtrak. Ironically, the creation of Amtrak led to a stalemate regarding intercity passenger rail's relationship with other transportation modes and with government. As discussed on the first chapter, since its creation, Amtrak's relationship with other modes has been characterized by a division between passenger and freight rail and the isolation of the former from earmarked tax returns and cooperative planning and management. Both of these issues also plague HSR efforts, along with other political and financial difficulties **[17]**.

Since 1980, there have been 19 efforts to develop and deploy some form of HSGT in the U.S. These projects have taken different forms, both in terms of business models (which range from entirely public led and financed, to privately funded, to public private partnership) and in the type of technology they have sought to employ. Some of these projects have been formally designated by the U.S. DOT as federal HSR corridors or identified under the FRA's Maglev program. Such identification opens the door for federal funding that might not be available otherwise. Other projects have been pursued without federal designation, although several (as in Nevada) are hoping to achieve this status. Complicating the situation is the fact that in some cases, states or groups of states have been pursuing HSR systems that include all or part of federally designated corridors, but expand upon them by adding additional linkages.

While incremental and new HSR projects differ in several ways, both the basic technologies and the markets they would serve are similar. Maglev is fundamentally different than HSR: it uses a completely different technology; it offers competitive service at a broader set of distances (40 to 600 miles versus 100 to 500 miles); and its federal funding sources are different.

4.2 Case Studies: Japan, Spain and France

Before starting to study the different HSR projects that have been proposed or existed in the U.S. during the last decades, it would be interesting to take an overview on three of the most important countries in the world with HSR systems. Reviewing the background, funding, operations and infrastructure of the HSR in these countries, will give us a better idea to start analyzing the HSR in the U.S..

4.2.a Japan

Background: Japan was the first country in the world to develop HSR operations, which occurred in 1964 with the opening of the Shinkansen between Tokyo and Osaka. In addition, in 1970, the Nationwide Shinkansen Railway Development Act was established, which created a master plan for the expansion of HSR lines throughout Japan. After this, four HSR lines were constructed prior to the 1987 reform of the passenger rail industry in Japan. The 1987 reform broke the fully integrated state railway entity, Japanese National Railways, into six private intercity passenger rail operators based on six distinct geographic regions (see Figure 25), as well as a freight operator. Since then, three HSR lines have been built under the reformed structure, and the HSR system continues to expand on the basis of the HSR master plan. The length of the Japanese HSR system is about 1,360 miles and its ridership in 2006 was approximately of 300 million. The top commercial speed of its trains is 188 mph **[L]**.

Funding: Prior the 1987 reform, the construction of HSR in Japan was funded through debt incurred by the national government and JNR. After the 1987 reform, the national government funds two-thirds of the construction cost, and local governments fund one-third of the construction cost under the Nationwide Shinkansen Railway Development Act. The national government funding is derived from the revenues from the sale of rail lines to private companies and the national public works budget. Private companies purchased the four constructed HSR lines from the national government in 1991, and in turn the companies have to pay an annual fee to the national government for 60 years. For HSR lines built after the 1987 reform, the companies pay a lease payment to the Japan Railway Construction, Transportation, and Technology Agency for the use of the HSR lines, on the basis of projected ridership. The national government does not provide operating subsidies for HSR passenger operations **[18]**.

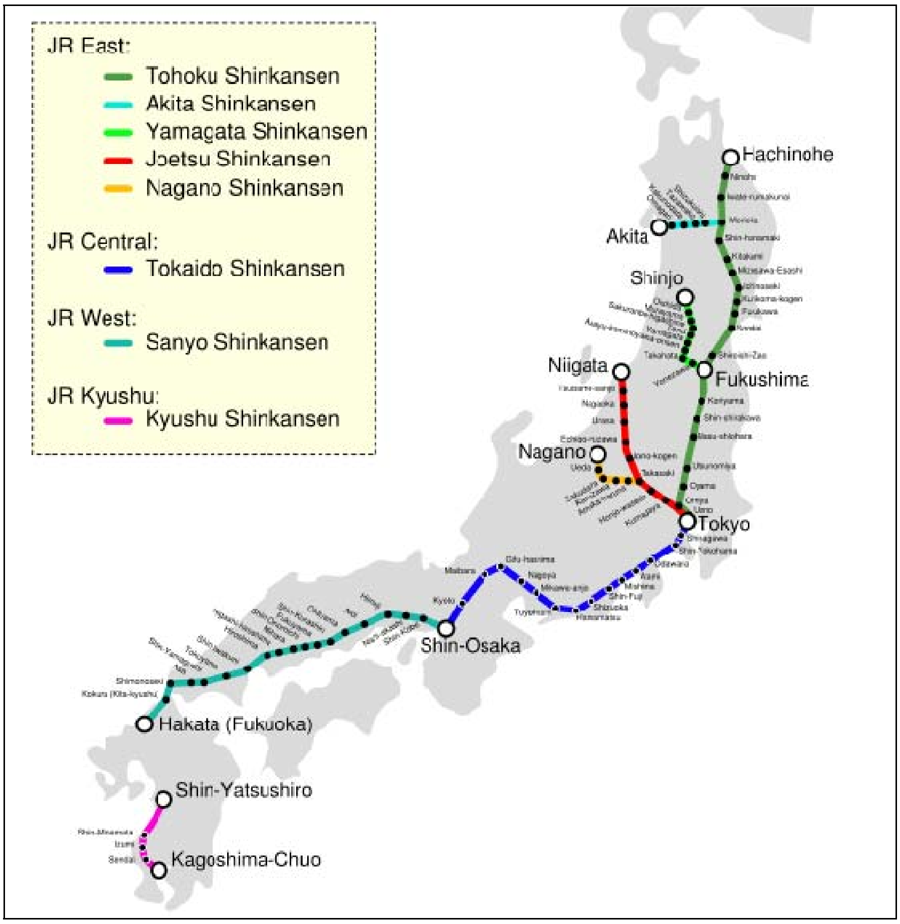

Figure 25. Japan's HSR Network (Source: [M])

Operations: Prior to the 1987 reform, JNR was a fully integrated state-owned entity that was the sole HSR operator in Japan. After the 1987 reform, JNR was split into six private operators, three are on the mainland (JR East, JR Central, and JR West) and the other three are each on an island (JR Hokkaido, JR Shikoku, and JR Kyushu). JR East, JR Central, JR West, and JR Kyushu operate HSR lines. JR East operates Shinkansen lines between Tokyo and Nagano, Tokyo and Niigata, and Tokyo and Hachinohe; JR Central operates the Shinkansen line between Tokyo and Osaka; JR West operates the Shinkansen line between Osaka and Fukuoka; and, JR Kyushu operates the Shinkansen line between Kagoshima and Shin Yatsushiro. The three mainland operators are considered fully privatized entities **[19]**.

Infrastructure: HSR lines built after the 1987 reform are constructed and owned by the Japan Railway Construction, Transportation, and Technology Agency, and are leased to the JR companies. As a result of the 1991 law, JR East purchased the HSR line from Tokyo to Niigata and the track from Tokyo to Morioka. JR Central purchased the HSR line from Tokyo to Osaka, and JR West purchased the HSR line from Osaka to Hakata.

4.2.b <u>Spain</u>

Background: Spain first developed HSR lines with the opening of the Madrid to Seville line in 1992. Since then, Spain has constructed additional HSR lines from Madrid to Barcelona and Madrid to Valladolid, in 2007 and 2008, respectively, and from Córdoba to Málaga, with extensions built off these main lines as well (i.e., to Toledo in 2005). The construction of these lines was based on a national rail plan created in 1987 and national transportation plans created in 1993, 1997, and 2005. In 2005, Spain's railway system was restructured in accordance with the European Union directive requiring the separation of passenger operations and infrastructure management. In accordance with these directives, Spain passed its own legislation, which split its state railway entity, RENFE, into two entities, ADIF and RENFE-Operadora. ADIF is responsible for infrastructure management and capacity allocation, and RENFE-Operadora is responsible for passenger operations. The Ministerio de Fomento (Ministry of Public Works) is responsible for setting policy, enforcing laws and regulations, and approving and financing projects. Spain most recent national transportation plan calls for $103.9 billion in investment for creating 5,592 miles of HSR lines. The actual length of the Spanish HSR system is 981 miles (Figure 26); it has a top commercial speed of 186 mph and a ridership of 9 million passengers in 2007.

Funding: After the 1997 European rail legislation, Spain created ADIF, a state-owned company under the Ministry of Development, similar to RFF in France. Of the HSR lines built since then, construction costs have been derived from funding from the national government, the European Union, and ADIF. A majority of funding to construct the Madrid to Seville HSR line was provided by the national government. Moving forward, it is planned that funding for expansion of the existing HSR network will be derived from the national government, local governments, ADIF, and loans from the European Investment Bank. For cross-border HSR lines, it is also planned that funding will be derived from the

European Union as part of the Trans-European Transport Network **[20]**.

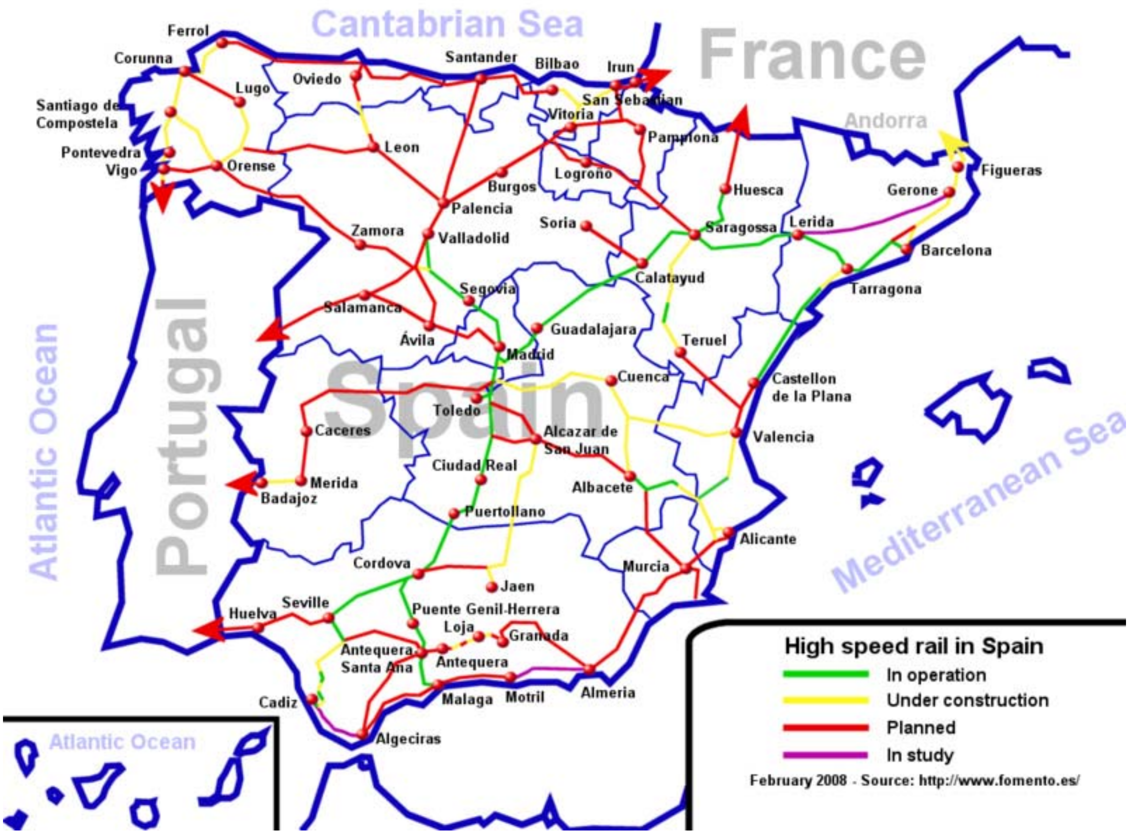

Figure 26. Spain's HSR Network (Source: [N])

Operations: RENFE-Operadora is the sole provider of HSR operations in Spain. According to European Union directives, international HSR lines must be opened to competition starting in 2010. Therefore, Spain will be required to allow private and public competitors to operate their trains over these international lines.

Infrastructure: *I*n terms of track ownership, ADIF owns the current HSR lines as well as passenger rail stations, freight terminals, and the telecommunications network. In addition, ADIF constructs and maintains HSR lines, allocates capacity to passenger rail operators, and manages traffic control operations and safety systems. RENFE-Operadora pays ADIF infrastructure fees to use the HSR lines.

4.2.c <u>France</u>

Background: France first developed HSR lines with the opening of the TGV Sud-Est line from Paris to Lyon in 1981. Since then, France has constructed additional HSR lines connecting major cities in France, as well as connecting HSR lines to cities in Germany, Belgium, and the United Kingdom. The rail business model in Europe was strongly affected by 1997 European legislation which required the separation of passenger operations and infrastructure management. This legislation was enacted to standardize the business model structure in Europe and led to the creation of nationwide rail network infrastructure managers in Europe. The French railway system had undergone a major reform with this legislation, creating on 1997 the RFF, France's national intercity rail network infrastructure manager. In addition, the ownership of the rail network, including the HSR network, was transferred from the national government to RFF. RFF is also responsible for capacity allocation, contracting, traffic management, and maintenance, although it subcontracts the traffic management and maintenance to the passenger rail operator, SNCF. The Ministry of Ecology, Energy, Sustainable Development, and Spatial Planning sets policy, enforces laws and regulations, and approves and finances projects. Moving forward, France is pursuing a HSR plan on the basis of a recommendation from a national environmental conference (Le Grenelle Environnement), which called for investments in sustainable transportation modes **[21]**. Specifically, it recommended building about 1,200 miles of additional HSR lines before 2020 and studying the viability of another approximately 1,500 miles of HSR lines. The actual length of the French HSR system is 1,180 miles (Figure 27). Its top commercial speed is 199 mph (320 km/h) and the ridership of the system was approximately of 100 million in 2007.

Figure 27. France's HSR Network(Source:[O])

Funding: Prior to the creation of RFF in 1997, most of the funding for the construction of HSR lines came from the national government (through SNCF). Since then, funding for HSR construction is derived from a variety of sources, including the national government, regional governments, RFF, SNCF, and the European Union.

Operations: SNCF is the sole provider of domestic HSR operations in France. The Eurostar and Thalys TGV, of which SNCF is a shareholder, provide international HSR operations to locations in Belgium, Holland, and the United Kingdom. According to European Union directives, international HSR lines must be opened for competition starting in 2010. Therefore, France will be required to allow private and public competitors to operate their trains over these lines.

Infrastructure: In terms of track ownership, RFF is an owner of all intercity railway property in France. RFF is also responsible for allocating capacity for the HSR infrastructure and for the maintenance and management of traffic of the HSR system. However, these responsibilities have been subcontracted to SNCF. SNCF pays RFF infrastructure fees to use the HSR lines.

4.3 Previous HSR Attempts in the United States

Since the 1980s, there have been several failed attempts to implement HSR in the U.S.. The most notable of these were the Pacific Northwest projects on the states of Oregon and Washington (1992-2001), the Texas TGV to link Dallas/Fort Worth, Houston, and San Antonio (1989-1994), and the FOX project to link Miami-Orlando-Tampa Bay (1991-1999).

It is very important to analyze the following three case studies that offer interesting counterpoints and put the reader in a familiar environment in regard to the HSR in America. In the history of Florida there have been two HSR projects, one was a new HSR plan and the other was an incremental system. The case of the Pacific Northwest focused on an incremental HSR and was driven mainly by state agencies. It has demonstrated the difficulties of the efforts of several states, while the Florida case showed that state efforts alone are also often hard. In Texas, the funding problems between the public and private sector killed the TGV project.

4.3.a <u>Florida</u>

The history of HSR in Florida covers more than 30 years including several starts and stops, numerous corridor studies and proposals, and millions of dollars in investments. It is a state with an anti-tax culture and is historically dependent on the automobile, with little commuter rail or transit.

In 1976, the Florida legislature mandated the Florida Transit Corridor Study to determine the feasibility of HSR between Daytona Beach and St. Petersburg. The study concluded that, if implemented in stages using existing highway corridors, HSR would be marketable in Florida. The study proposed using existing rail corridors and the possibility of locating HSR within limited access highway medians, an idea with which the FDOT agreed.

Six years later, in 1982, Governor Bob Graham (D, 1979–1987) visited Japan and traveled on the Shinkansen. He returned to Florida a strong supporter of HSR and authorized the creation of the FHSRC, a Florida HSR Committee, as a first step toward creating such a system in his state. In 1984, the committee released the Florida Future Advanced Transportation Report, which concluded that Florida's transportation infrastructure could not accommodate future growth and that an advanced HSR system was necessary to maintaining mobility in the state. The report recommended developing public-private partnerships and using existing publicly owned ROWs. During that same year, Florida's legislature enacted the FHSRTCA, a Commission Act, which created the seven-member FHSRC and authorized it to grant a franchise to build a privately funded and operated HSR network serving Miami, Tampa, and Orlando **[P]**.

In 1986, the HSR Commission released its own study by Barton Aschman Associates that recommended proceeding with a 356-mile HSR system connecting Miami, Orlando, and Tampa. Requests for proposals were issued; two were received in 1988, one from Florida TGV, Inc., and one from Florida HSR Corporation. The former proposed using French TGV trains, which could run at speeds of 170 mph. The estimated cost of building the system was $2.2 billion, with ridership projections of 5.9 million annually. The latter proposed using Swedish-built ABBX2000 trains with tilt technologies that could run at speeds of 150 mph. Estimated costs were $1.9 billion, with projected ridership at 3.7 million annually. Both proposals assumed some public spending and/or real estate development rights, but when it was clear that there would be no support for public funding, Florida TGV, Inc., withdrew.

Florida HSR Corporation submitted a revised proposal in 1990 that proposed financing the project with a combination of tax increment financing, benefit districts, impact fees, and a new gas tax. One year later, Governor Lawton Chiles (D, 1991–1998) rejected the proposal, citing high costs. Despite the lack of support in the governor's office, the legislature enacted a new HSR Act in 1992, transferring the FHSRC's responsibilities to FDOT. FDOT also was charged with providing an updated rail system plan every other year that incorporated both passenger and freight components. That same year, on October 16, the Miami-Orlando-Tampa Corridor was federally designated as a HSR corridor by the U.S. DOT, allowing the possibility of federal funds for studies. During the next two years (1992-1994), more corridor studies were conducted by FDOT to evaluate the feasibility of a network of HSR corridors connecting major cities around the state. Based on the findings of these studies, FDOT announced its commitment to fund HSR, setting aside $70 million per year, plus a 4% inflation adjustment, for at least 30 years. The funds would service infrastructure bonds using a portion of Florida's gasoline tax that had been earmarked for non-highway expenditures **[22]**.

In 1995, five proposals were submitted, offering a range of public-private options for the Miami-Tampa-Orlando corridor, including plans aimed at incremental improvements, new HSR using bullet trains, and two proposals for Maglev technologies. Cost estimates on the proposals ranged from a low of $740 million to a high of $20 billion. After evaluating the proposals, FDOT selected the FOX. FOX proposed to build and operate a new grade-separated, fully dedicated HSR serving the three cities at an estimated capital cost of $6.1 billion. FOX officials felt strongly that sharing tracks through an incremental approach would never allow the speeds and frequency of service of a dedicated ROW.

Like the earlier proposal from Florida TGV, Inc., FOX planned to use French TGV technology for its rolling stock. Although other technologies were available, the selection of the TGV was aimed at minimizing risk, particularly in the eyes of the financial industry. Because HSR did not exist in the U.S., it was (and still is) considered a high-risk venture; using a proven technology could at least mitigate risk on the technological side. In revenue service since 1981, the TGV had demonstrated the fastest trip times, the most reliability, and the best safety record of the potential technologies available. Envisioned as a private-public partnership, franchise and precertification agreements were executed in 1997, with the understanding that FDOT would provide $70 million per year (escalated at 4% per year) for 30 to 40 years. Using a portion of Florida's gasoline tax revenues, a percentage of which had been earmarked for non-highway related expenditures, these funds would be used to service infrastructure bonds. FOX would contribute $349 million in equity funds over the construction period to capitalize FOX. Although a significant amount of money, the $349 million only accounted for 4% of the total projected costs (see Figure 28), estimated at up to $9.3 billion total. The remainder of the costs would be financed through debt financing and bonds, repaid by revenues and a portion of the annual state contributions, although $2 billion in federal loans through the Transportation Infrastructure Finance and Innovation Act (TIFIA) were also sought.

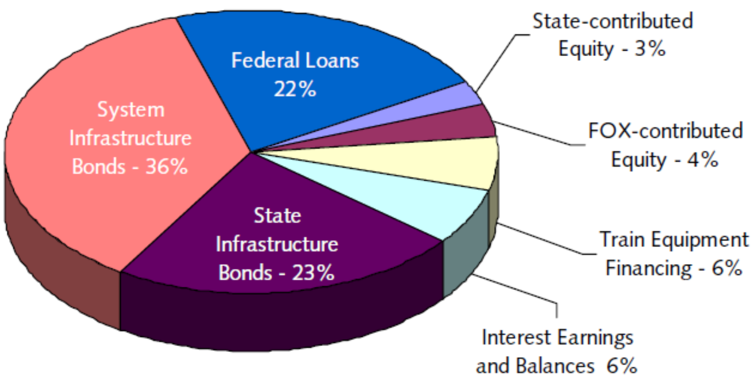

Figure 28. Sources of Funding for the FOX Project (Source: [22])

FDOT viewed the project as playing a key role in an integrated transportation system that would link various modes and meet the travel needs of tourists and residents, while being environmentally and fiscally responsible. Regarding the need for a HSR project, some studies noted that Florida's population grew by 91% between 1970 and 1990, and they projected an additional increase of 38% by 2010. Tourism was projected to increase by 82% during that same period. Increased numbers of residents and tourists was expected to create a tremendous increase in demand for highway capacity that would exceed the projected 18% increase in highway lane miles through 2010.

Bolstered by these findings and FDOT's support, FOX began its preliminary engineering and environmental work in 1998. Opponents quickly sprang up, questioning everything from costs and environmental issues to the use of imported technology. A grassroots campaign called Derail the Bullet Train actively campaigned against FOX, suggesting that the new HSR project would lead to "an ineffective use of public money." State Senator Ron Klein, founder of Derail the Bullet Train, said that public transportation was and continues to be underdeveloped in Florida and, given the costs involved, he and many others would rather see such funds used toward regional forms of public transportation than intercity HSR. Others began poking holes in FOX's ridership projections and revenue estimates, often arguing that the U.S. was unlikely to follow European and Asian experiences with HSR. Although FOX's ridership study was said to have included "a more intense review and detailed ridership study than anywhere else in the world" at that time, many were skeptical because there was no HSR in the U.S. For example, FOX assumed that some airlines would agree to code-share agreements so travelers could easily transfer from planes flying into the cities onto HSR, as was done in Europe. FOX also assumed that some air passengers would choose HSR over air because of lower fares. However, the report stated that in many cases, air fares were already much lower than FOX projections. It also was assumed that more than 50% of the riders would be automobile drivers who would shift mode. Many people thought that FOX's ridership and revenue projections were too optimistic in an environment in which HSR was unproven.

Shortly thereafter, U.S. House Budget Committee Chair John Kasich (R-Ohio) asked the U.S. GAO to review FOX's proposal. GAO noted that because it was in the early phases of development, the FOX project faced "several uncertainties regarding its cost, ridership, and schedule… It will be at least 2 more years before sufficient information would be available to comprehensively assess the project". The review had a strong chilling effect, especially among potential investors, and lent further credence to concerns over the ability to secure federal funding for the project. Upon taking office in January 1999, Governor Bush terminated funding (as Governor Chiles had eight years earlier), citing both environmental and financial concerns and the uncertainties identified in the GAO report. The funding that would have been used for HSR was redirected toward highway and aviation projects, dealing a devastating blow to HSR.

In May 2000, Amtrak and FDOT issued the joint Florida Intercity Passenger Service Rail Vision Plan. It took a different approach to HSR, focusing on incremental rather than new HSR. Although the FOX project was not implemented, the benefits of rail were recognized by FDOT. The Vision Plan connected major urban centers, tourist attractions, and intermodal transportation centers.

The Vision Plan remains in place and has some support, but many in Florida are skeptical of incremental HSR. Although an incremental approach may be cheaper, it is still not cheap, and the issues of funding and public investment still need to be resolved. Finally, finding political support for incremental rail remains difficult because one still needs to make the case for a statewide benefit. With either this approach or with new HSR built in segments (for example, Tampa - Orlando first, then

Miami, then other cities), many people do not see initial benefits where they live or work and wonder if they will see a benefit to their region, given the costs and time involved.

In 2000, the Florida legislature authorized another feasibility study, initially titled the Coast-to-Coast Rail Feasibility Study and later renamed the Cross-State Rail Feasibility Study, to be conducted by STV, Inc. At the same time, the legislature asked voters to decide on a constitutional amendment. It passed with 52.7% of the popular vote, although regional differences existed: On a county-by-county basis, 30 counties voted in favor and 37 against the amendment. The legislature enacted the FHSRA Act in June 2001. FHSRA was charged with locating, planning, designing, financing, constructing, maintaining, owning, operating, administering, and managing HSR in the state. It was further authorized to “seek and obtain federal matching funds or any other funds to fulfill the requirements of this act either directly or through the DOT.” It appeared that progress was again being made.

The FHSRA proceeded initiating a Project, Development, and Environment (PD&E) Study in late 2001. The first report of the FHSRA to the governor was made in 2002. Later that year (on October 7), the FHSRA issued a request for proposals for the design, build, operation, maintenance, and finance (DBOM&F) of a HSGT. Around that same time, the FHSRA also released several documents as part of the PD&E Study, including the Florida HSR: Screening Report and the Investment Grade Ridership Study **[23]**. The former documented the initial decision-making process used to determine which segments within the potential corridors between Orlando and Tampa would be moved forward for further analysis. It also reviewed the need, purpose, and markets for HSR in Florida noting tourist travel, commuters, businesses and freight movement

In August 2003, after two of the four proposals submitted were found to be preliminarily responsive to the 2002 Request for Proposals, a Draft Environmental Impact Statement (DEIS) was issued for the Tampa-to-Orlando HSR, noting that “the purpose of the proposed project was to enhance passenger mobility between Tampa and Orlando” and that such mobility “was viewed as essential for the sustained economic growth of the region, as well as the quality of life of the region’s residents and visitors. After taking into account the potential impacts and revenues for each of the technologies, running in each of the four possible alignments, the FHSRA named Fluor-Bombardier as the first-ranked proposer and selected the Greeneway as the preferred alignment in Orlando, noting that the environmental impacts for both Orlando alignments were similar but the Greeneway alignment offered a potential for higher ridership revenues, lower cost, and the least financial risk. The FHSRA executed a contract with Fluor-Bombardier to provide professional services in support of the completion of a Final EIS (FEIS), to be conducted at no cost to the FSHRA or the state. Work on the FEIS began in January 2004. By the end of 2003, the Florida Legislature had authorized $14 million for the HSR project, but then Governor Bush vetoed $5 million of those funds and stated he would not support further new HSR efforts **[24]**. Governor Bush and Thomas Gallagher (Chair of Derail the Bullet Train and state CFO), actively engaged in the campaign to repeal the amendment in November 2004. By June 1, 2004, they had 54,774 signatures deemed valid, but for the repeal to appear on the

November 2004 ballot, they needed 488,722 signatures. By November of that year, however, enough signatures were declared valid that the repeal was placed on the ballot and was overwhelmingly supported in the November 2004 general elections, with 63.7% voting for the repeal.

For 30 years, the state of Florida has pursued HSR in one form or another. Each time progress is made, setbacks occur and the process begins again. The situation now appears to be more of a stalemate with three discernible positions: those advocating new HSR, those opposed to all HSR plans, and those who want an incremental approach. However, Florida's experience offers some powerful lessons and issues for consideration for HSR elsewhere in the country.

4.3.b **Pacific Northwest**

When Amtrak assumed passenger rail services from the railroads in May 1971, it continued limited passenger service. There was one train on the Burlington Northern (BN) Railway track between Portland, Oregon, and Seattle, Washington. There was another additional Amtrak train per day, the Coast Starlight between Seattle and Los Angeles, which ran on the BN between Seattle and Portland and on the Southern Pacific between Portland and Eugene, Oregon. There was no rail service between Seattle and Vancouver, B.C., after 1981.

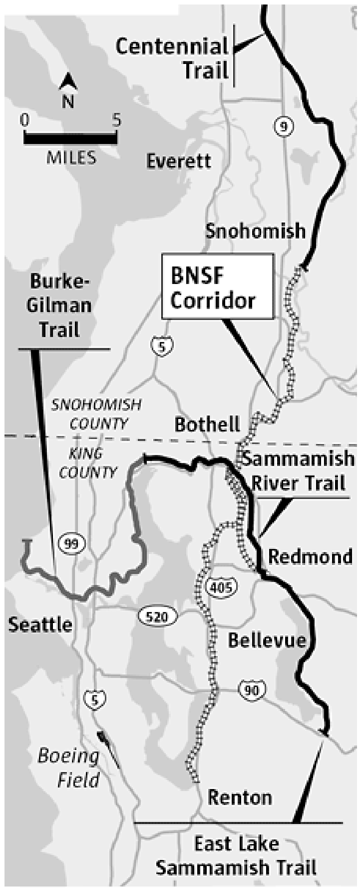

Figure 29. BNSF Corridor (Source: [Q])

Often, it's been told that people in the Pacific Northwest pride themselves on environmental sensitivity and look for ways to reduce reliance on the environmentally unfriendly automobile. For example, Figure 29 shows important hiking and biking trails together with the BNSF rail corridor. This has led to attacks on the automobile culture in the public at large and required a change of philosophy about railroads. In the 1980s, however, sentiment began to grow in Washington State to develop the obsolete rail passenger service into a modern, high-speed, high-intensity rail corridor. The Washington State Legislature began funding improvements to railroad stations, apparently a first step toward the treatment of a rail passenger system as a state concern, not simply an obligation of Amtrak and the private railroad companies.

Similar efforts were underway in state of Oregon. The state withdrew funding between Portland and Eugene in 1980 and 1981 and the trains were discontinued officially because of lack of funds. In fact, ridership had been low because of poor schedule adherence and substandard track conditions on the Southern Pacific line. It was easier and faster to drive. The Oregon Legislature established a State Rail Rehabilitation Fund in 1985, but never appropriated money for it.

In 1991 Congress passed ISTEA, which, among other things, required the U.S. DOT to identify potential major HSR corridors. In 1992, the U.S. DOT identified the Pacific Northwest Rail Corridor (PNWRC) as one of five potential HSR corridors. This designated corridor extended from Washington State south to Eugene, Oregon, and north to Vancouver, B.C.

Washington efforts preceded ISTEA. In the late 1980s, the legislature requested the WSDOT to conduct a “HSGT Study.” Upon enactment of ISTEA, the Washington State Legislature took the next formal step with a directive to WSDOT to develop a “comprehensive assessment of the feasibility of developing a HSGT system in the State of Washington”. WSDOT responded in October 1992 with a HSGT Study, which confirmed the feasibility of HSR in Washington. Based on that study, the Washington legislature in April 1993 directed WSDOT to develop “high-quality intercity passenger rail service through incremental upgrading of the existing service”. WSDOT had used the term “high-speed”; the Washington legislature did not. The legislature specifically wanted to build a “rail culture” to “make rail a competitive and viable alternative to automobile and commuter air travel **[25]**.

Unlike Washington, Oregon’s plans did not specify high-speed. Oregon DOT would be happy if two or three additional trains could traverse the 124 miles from Portland to Eugene in 2 hours, 15 minutes, an improvement of only 20 minutes over current scheduled performance. In a brief three paragraphs, the 2001 ORP dismisses HSR; that is, train speeds in excess of 150 mph. Oregon is pursuing an incremental approach, as “an effective plan...that can be implemented in the next six years.” Oregon calculates that real HSR would cost 12 to 15 times as much as the incremental plan, but would only attract five times as many riders. This thinking reflects highway planner logic, as if the comparisons were between two different highway alternatives. The three-paragraph dismissal of HSR in 2001 ORP makes no effort to place any value on the consequences that might result if significantly more riders choose to use rail instead of the highway. Oregon does not compare the cost of rail per mile with the cost of a highway per mile, as WSDOT does.

The incremental approach: The Washington legislature specified an incremental approach to what was loosely termed HSR. Many reasons were given for an incremental approach instead of a new dedicated HSR system like better chance to obtain funding over a period of years, market demand-driven development, rail culture development, freight improvement and less costly.

The most important development was the WSDOT decision to experiment with Talgo technology. As discussed in a following chapter, this Spanish technology features a pendular process that allows rail cars to tilt on curves. Tilting makes the ride on curved track more comfortable to passengers and allows faster operation on curves. Talgo trains also are lightweight, have a low center of gravity, and are articulated, creating smoother ride on curved track. The trains are largely manufactured by the Talgo Company in Spain, with some final assembly performed in Washington to comply with local-manufacture requirements. Talgos have been used successfully in Europe for many years. Washington leased two Spanish Talgo trains in 1995 for use on the PNWRC, and Amtrak operates them under the marketing name “Cascades.” Oregon began to support the service in 1995 and paid

Amtrak to extend one Cascade per day from Portland to Eugene. Washington paid to extend one Cascade per day to Vancouver, B.C. The introduction of the Talgos, reduced the operating time from Seattle to Portland by 30 minutes, largely due to higher speed capability on curves.

WSDOT initiated the experiment with Talgo technology in 1993, before WSDOT published the various studies in response to ISTEA. The trains were popular with passengers, so Washington returned the leased Talgos and bought two new, customized Talgo trainsets. Amtrak also bought two such trainsets. Talgo built a fifth trainset on spec and leased it to Oregon in 1999. Seattle-to-Portland ridership in 1993 was 94,000 per year; it grew to 590,000 per year by 2003. The increase of ridership on the PNWRC started being large due to the popular introduction of the Talgos. Talgos are designed for European standards, and have some minor discrepancies with FRA train regulations. The FRA waived the discrepancies but limited operation to a maximum of 79 mph because PNWRC track conditions will not support speeds in excess of 79 mph. BNSF engineers, worried about increased rail wear on curves, studied the issue and determined that the Talgos did not materially increase wear on rails.

4.3.c <u>Texas TGV</u>

In 1982, a Texas legislature joint committee recommended that feasibility studies were examining the potential of conventional rail and HSR between Texan cities. Proposed legislation to enact the joint committee report recommendations, failed. Three years later, a German Consortium reported that a HSR system would be viable from Dallas to Houston if the project obtained $500 millions for startup contributions and was financed with tax exempt bonds. Two years later, the German Consortium unsuccessfully lobbied the Texas legislature to undertake the proposal. A job creation task force created by the then-Governor recommended that the Governor support enabling legislation for the Texas Turnpike Authority to conduct a HSR feasibility study. The enabling legislation passed.

In 1989, after receipt of the study, the Texas legislature created the Texas HSR Authority (THSRA). It was charged with determining if HSR was in the public interest and, if so, awarding a franchise to develop and operate such a system. During the next three years, the THSRA issues requests for proposals, in which two of three applications met the criteria. Texas TGV Corporation was ultimately granted the franchise after evidentiary hearings were held on franchise applications. Court dismissed lawsuits filed by Southwest Airlines to postpone the hearings and to rescind the rules of the THSRA. Texas TGV Corporation, the THSRA, and FRA signed a memorandum of understanding establishing environmental review responsibilities as well as other responsibilities. The 1993 security offering was for $200 million in notes, backed by a $225 million letter of credit from the Canadian Imperial Bank of Commerce and a $75 million counter-guarantee to be provided by Morrison Knudsen Corporation (one of the original project developers). The Texas HSR Authority Act prohibited use of public funds for constructing the system, and, as a result, all construction costs would have been privately financed.

After this, the THSRA and Texas TGV Corporation signed the franchise agreement and outlined responsibilities of Texas TGV Corporation, many of which were time-sensitive. Work began on environmental review and ridership studies, but environmental review work was eventually stopped because of cost overruns. The first portion of public financing offering of Texas TGV Corporation was delayed until December 31, 1993. The Texas TGV argued it was due to lack of progress on environmental review and investment grade ridership studies as well as other reasons.

During that year, delays forced renegotiation of franchise agreement, and additional requirements were placed on the Texas TGV Corporation. The corporation submitted a plan to the THSRA, which did not include required detailed financial and milestones information, and released its independent ridership study. Texas TGV Corporation issued its initial security offering as previously described. A day before the pricing and sale of the notes was scheduled to occur, Morrison Knudsen announced that it was no longer going to provide the counter-guarantee, and that the offering was going to be withdrawn. The Texas TGV Corporation could not meet its deadline of December 31, 1993, and next year, work was halted by the Texas TGV Corporation, which led to the termination of the franchise agreement. The Texas legislature abolished the THSRA and its enabling legislation.

Texas TGV's investors lost about $40 million by the end of the process. More importantly, according to **[17]**, "The Texas TGV's failure was a delegitimizing event for the proponents of market-led rail passenger renewal." The Texas Triangle is a clear example of a failure, as they are no longer actively pursuing funding or development.

4.4 The only success in the United States: The Northeast Corridor (NEC)

Although not formally designated as a federal corridor, the NEC is one of the few U.S. success stories in HSR; however, its key successes in terms of speed came by the early 1970s and there has been little improvement since then. However, while HSR in the NEC did not keep pace with the speed and reliability of European and Asian efforts, it did keep pace with respect to commercial performance by covering costs and generating an operating profit. Linking Boston, New York, Washington, and intermediate cities, the NEC main line on Figure 30, is America's most highly-developed HSR corridor.

Background: In 1967, following the High-Speed Ground Transportation Act (HSGTA) two years prior, the Office of HSGT at the U.S. DOT committed $6.7 million to support Pennsylvania Railroad's acquisition of new passenger cars that could attain speeds up to 160 mph. The goal was to shorten the trip between New York City and Washington, D.C., to less than three hours.

Figure 30. The NEC (Source: [D])

What made the NEC so marketable was a combination of economic and geographic circumstances. Because the NEC lacked the space to add the highway and air capacity needed to match growing travel demands, it was a good candidate for enhancing existing infrastructure. The corridor had a well-developed and modern rail infrastructure when the decision was made, and Pennsylvania Railroad, which owned and operated the line between New York City and Washington, D.C., was willing to work with the government on the initiative.

Funding: This was a true private-public enterprise as will be described later: Private partners put approximately $860 million into the project, with only about $13 million from government sources. The key manufacturing companies (GE, Westinghouse, and the Budd Company) were all U.S. based. The partners had the Metroliner HSR system up and running within four years. However, because the long-term goal of upgrading the tracks to accommodate the higher speeds was not yet met, the trains could only run at speeds as high as 120 mph **[26]**.

The partnership ended when Penn Central filed for bankruptcy in 1970, with other railroads following soon after. Amtrak took over operation of the Metroliner between New York City and Washington, D.C., between 1978 and 1999; FRA invested about $3.7 billion in rehabilitating and upgrading the corridor. In 1992, Amtrak initiated the Acela HSR program and has invested $1.8 billion to date in a system that could run at speeds of 150 mph. Work focused especially on the New York City–Boston segment of the corridor, rebuilding infrastructure and fully electrifying the line to Boston from New Haven, Connecticut.

Project's Goals/Scope: Revenue service of the Acela began in December 2000 and trains now operate between 110 and 150 mph on parts of the corridor (see Table 1). However, in more than 30 years, except for the introduction of the Acela, little has changed on the southern section of the corridor in terms of speed and number of trains making the trip on a daily basis, even as the airlines have modified their schedules to accommodate more passengers and more trips. This corridor is considered a success because the system has been operating at HSR speeds for several decades, although the ultimate goal has not yet been achieved on much of the line.

Segment	Mileage	Top Speed (Goal/Actual)	Travel Time (Goal/Actual)
Washington to New York	225	150/135 mph	2:50/2:43
New York to Boston	231	150/150 mph	4:10/3:24

Table 1. Top Speed and Travel Time Goals for the NEC (Source: [R])

The HSR trainsets designed and manufactured under the control of Bombardier for Amtrak, consist of power cars at the front and rear with 6 coaches (a first class car, four regular cars, and a café car in between, which is completely accessible to passengers with limited mobility; see Figure 31). The total capacity is of 304 passengers and it has a length of 665' 8 ¾'' and a width of 10' 5'. Advanced tilt technology in the trailer car provides a smooth, quiet, comfortable ride. In addition the train is particularly energy efficient and environmentally friendly as a result of the facility for saving braking energy, so-called regenerative braking.

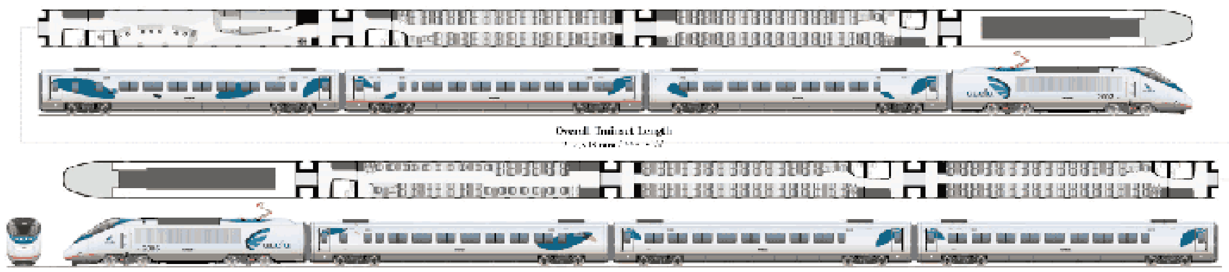

Figure 31. Schematic view of the Acela Express in the NEC (Source: [S])

5. THE 10 DESIGNATED HSR CORRIDORS

Today, at the end of 2009, up to eleven corridors are authorized for designation, of which the Secretary of Transportation and/or the Congress have designated ten of them. As said before, the NEC it has not been designated a HSR corridor. Of the designated corridors, three were specifically named by Congress in law. The other seven were selected by the Secretary of Transportation in a competitive process, which in current law involves an evaluation of such factors as projected ridership, public benefits, and anticipated partnership participation of States, localities, and the freight railroads. The next Figure 32 shows the 10 designated HSR and the NEC.

Figure 32. The 10 designated HSR corridors and the NEC (Source: [T])

The corridor authorization program was initiated on December 18, 1991 and the latest extension approved was on December 4, 2004. Since that date, no changes have been made. Five corridors (were authorized under the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and six were authorized under the Transportation Equity Act for the 21st Century (TEA-21) in 1998.

On the next page, Table 2 summarizes the different authorized corridors in the U.S. including the most relevant designation information for each one. Each HSR project in the U.S. has its own characteristics due to large differences between regions and States. The detailed study of each of the projects can become very large and complex, reason why this paper has tried to give an idea with general features of each corridor to achieve a global vision of the HSR in America.

Name of Corridor	Designation Date	Designated By	First Designated Links
Chicago Hub	October 15, 1992	ISTEA	Chicago - Detroit & St.Louis - Milwaukee
Florida	October 16, 1992	ISTEA	Miami - (Orlando & Tampa)
California	October 19, 1992	ISTEA	San Diego - (Los Angeles & Sacramento)
Southeast	October 20, 1992	ISTEA	Charlotte - (Richmond & Washington)
Pacific Northwest	October 20, 1992	ISTEA	(Eugene & Portland) - (Seattle & Vancouver)
Gulf Coast	November 18, 1998	TEA-21	New Orleans - (Houston & Atlanta)
keystone	December 10, 1998	TEA-21	Pittsburgh - Philadelphia
Empire State	December 10, 1998	TEA-21	New York City - Buffalo
Northern New England	October 11, 2000	TEA-21	Boston - (Portland & Montreal)
South Central	October 11, 2000	TEA-21	Dallas - (Austin & Oklahoma)

Table 2. HSR Corridors and Designations(Source: [T])

To describe the various HSR corridors, a summary of the most relevant information for each corridor has been created through the following broad headings: Corridor Brief’s Description, Background, Project's Goals/Scope and Actual Status. In the next chapter there will be a discussion of the different technologies that the different corridors are planning to implement.

The description of all the corridors has been classified in clockwise order starting with the Chicago Hub Network and finishing with the Pacific Northwest Corridor. In this way, the reader can have a better orientation around the country when reading the different HSR corridors. The following lines show all the basic information of each of the 10 designated corridors.

5.1 Chicago Hub Network

Corridor Brief’s Description: The Chicago Hub is a hub-spoke model that runs out of Chicago, Illinois (see Figure 33). One line runs north to Milwaukee, Wisconsin, before veering northwest to Minneapolis/St. Paul, Minnesota. A second line runs south from Chicago to Springfield, Illinois, and St. Louis, Missouri, before veering west to Kansas City, Missouri. A third line runs south to Indianapolis, Indiana, where it branches into two lines, one running south to Louisville, Kentucky, and another running to Cincinnati, Ohio. A fourth line runs east from Chicago to Toledo and Cleveland, Ohio. That line then runs south to Columbus, Ohio, before joining the third line at Cincinnati, Ohio. Finally, a fifth line runs east from Chicago to Kalamazoo and Detroit, Michigan.

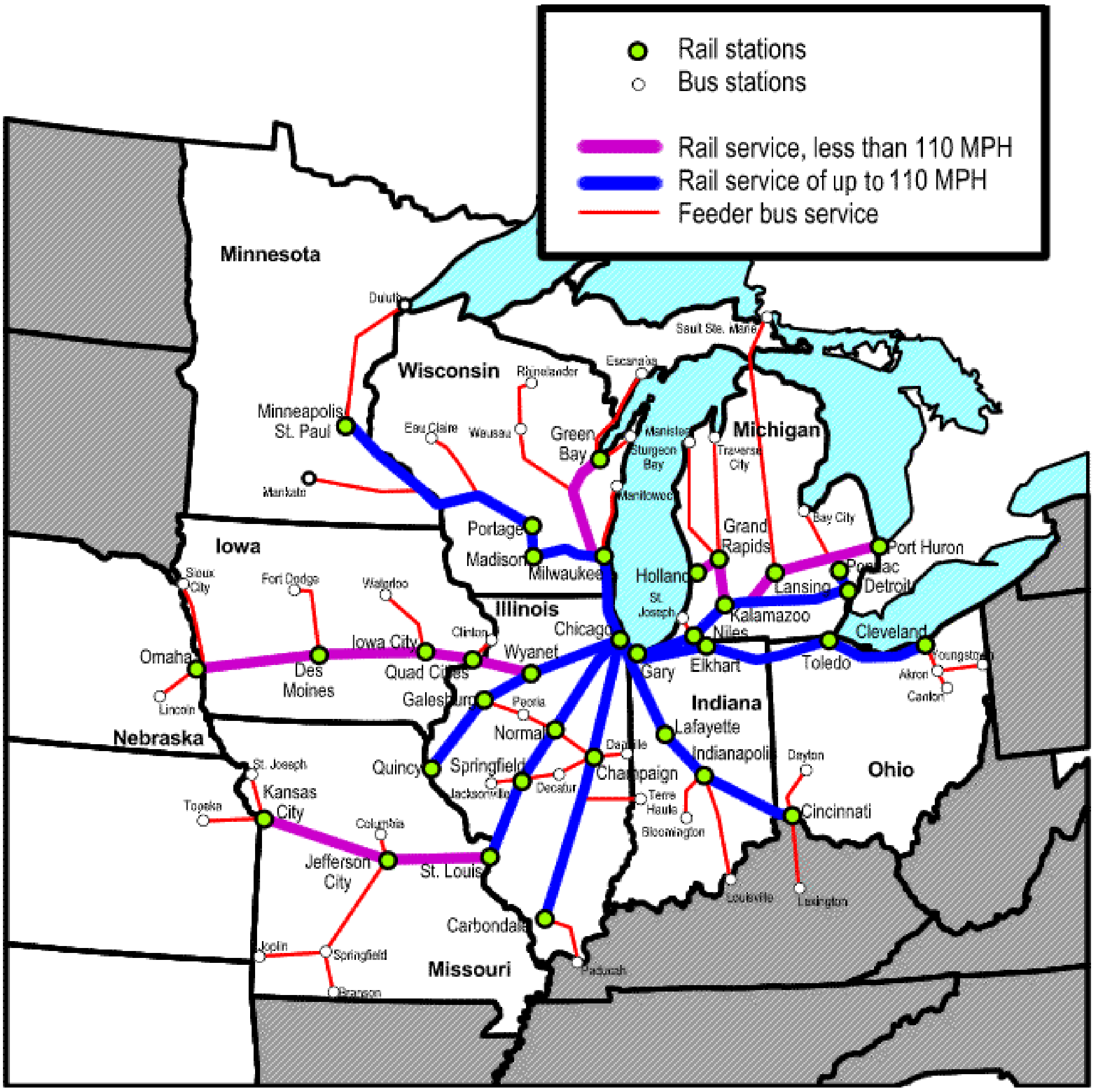

Figure 33. Chicago Hub Network (Source: [U])

Background: In 1990, the States of Illinois, Minnesota, and Wisconsin signed a Memorandum of Understanding (MOU) aimed at evaluating the potential for a HSR corridor linking Chicago, Milwaukee, and Minneapolis - St. Paul. One year later, TMS/Benesch HSR Consultants presented their report, Tri-State HSR Study: Chicago – Milwaukee - Twin Cities Corridor, to the Departments of Transportation of the three states. The purpose of the report was "to investigate the economic and financial potential for constructing and operating a HSR rail system in one of two corridors between Chicago and Minneapolis - St. Paul." The corridors examined were a southern corridor linking Chicago, Milwaukee, and the Twin Cities via Madison, and a northern corridor linking the same cities via Green Bay. The study concluded that the southern corridor appeared "very promising in terms of ridership, revenues, financial, and economic benefits." The report recommended using existing ROW and targeting 125 mph service. By 1994, Illinois planners had completed a study of 125 mph service for the Chicago - St. Louis spoke, and the second phase of a study focused on the Chicago - Milwaukee spoke recommended incremental nonelectric HSR at 125 mph.

In April 1997, Illinois entered into a cooperative agreement (DTFRDV-96-H-60006) with the U.S. DOT to perform a Tier I environmental impact study (EIS) of the Chicago - St. Louis spoke of the Chicago Hub Network. The final EIS, released in January 2003, proposed that HSR passenger service between Chicago and St. Louis be implemented with a maximum operating speed of 110 mph on the section south of Dwight and ongoing speeds of 79 mph north of Dwight. Running parallel to the EIS efforts, nine Midwestern states (Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Nebraska, Ohio, and Wisconsin) joined to form the Midwest Regional Rail Initiative (MWRRI) in 1996. The goal was to develop an implementation plan for a more extensive HSR centered on the Chicago Hub. Totaling 3,000 miles, the MWRRI includes the federally designated corridors in the Chicago Hub Network, and adds additional passenger rail links at various speeds above and below 110 mph, as well as several feeder bus service links. The following additional proposed city links are not federally designated:

- Milwaukee, WI – Green Bay, WI
- Chicago, IL – Quincy, IL
- Chicago, IL – Iowa City, IA – Des Moines, IA – Omaha, NE
- Chicago, IL – Carbondale, MO
- Kalamazoo, MI – Grand Rapids, MI – Holland, MI
- Kalamazoo, MI – Lansing, MI – Port Huron, MI
- Detroit, MI – Pontiac, MI

In 1998, the Midwestern Legislative Conference formed a HSR Task Force. Out of that task force, the Midwest Interstate Passenger Rail Commission (MIPRC) was formed by a compact in 2000. The MIPRC works with the MWRRI, providing an advocacy arm for HSR in the region.

The Chicago Hub Network gives a complex picture of federally designated and non-federally designated corridors. There also is a strong rail component, as the state of Illinois pursues its Chicago Regional Environmental and Transportation Efficiency Program (CREATE) in tandem with HSR efforts.

Project's Goals/Scope: In 2002, Amtrak and the states of Illinois and Wisconsin began reviewing proposals for 110 mph tilting HSR trains. According to Amtrak, the state of Michigan, Amtrak, and the FRA have developed a state-of-the-art incremental train control system that permits passenger train operations on the existing ROW at speeds up to 110 mph. The first phase of the system (up to 90 mph on 45 miles of track along the Chicago - Detroit spoke) was implemented in January 2002. Work began to extend the system an additional 20 miles and to seek approval for operations at speeds in excess of 90 mph (see Table 3). Speeds have been increased to 110 mph on this section in southwest Michigan.

City Linkages – Federally Designated	Distance (miles)	Top Speed Goal (mph)	Travel Time (Hours)
Chicago, IL – Detroit, MI	279	110	3:49
Chicago – St. Louis, MO	282	110	3:50
Chicago – Milwaukee, WI – Minneapolis,MN - St. Paul, MN	445	110	5:52
Chicago – Indianapolis, IN – Cincinnati, OH	319	110	4:03
Chicago – Toledo, OH – Cleveland, OH	341	110	4:23
Cleveland – Columbus, OH – Cincinnati (3C)	254	110	3:28
Indianapolis – Louisville, KY	111	79	4:00
St. Louis – Kansas City, MO	282	90	4:14

Table 3. Chicago Hub Network Top Speed and Travel Times Goal (Source: [U])

Actual Status: Stated before, an EIS was completed almost 10 years ago for Chicago - St. Louis and an environmental document was prepared for the extension of Chicago to Milwaukee service on to Madison, WI. Work has begun along the Chicago - St. Louis spoke of the Hub Network and some rail is being replaced between Chicago and Milwaukee. In July 2009, Wisconsin officials announced a $47 million deal with the Spanish train manufacturer Talgo including two sets of 14-car passenger trains that will operate from Chicago to Milwaukee and will knock 45 minutes off the current 1-hour, 40-minute trip between this two destinations. Besides this, several other improvements have been made to upgrade the tracks to allow for 110 mph speeds on the south of the Dwight–Springfield portion of the spoke. A Positive Train Control system demonstration is underway along that same spoke.

With respect to the other spokes of the hub, Indiana has completed a series of HSR public outreach meetings to define the state's interest and participation in the MWRRI. Indiana is working with Amtrak, the states of Illinois and Michigan, and freight railroads on the South of the Lake Corridor Study to identify the best way to route passenger trains through southern Chicago and northwest Indiana. Minnesota is pursuing a $10 million capital budget request for preliminary engineering and environmental documentation for the Minnesota portion of the Chicago - Twin Cities (Minneapolis - St. Paul) corridor.

5.2 Northern New England Corridor

Corridor Brief Description: One of the newest of the federally designated corridors, the Northern New England Corridor (Figure 34) was formally designated in October 2000. Shaped like a lopsided V, the 489-mile corridor connects Boston with Portland and Auburn, Maine, on one side and connects Boston with Montreal, Canada, on the other. With Boston as its hub, the Northern New England Corridor would serve destinations in Maine, Massachusetts, Connecticut, New Hampshire, Vermont, and the Canadian province of Quebec.

Background: In January 2002, a meeting was held in Nashua, New Hampshire, to begin a Boston–Montreal HSR feasibility study, jointly funded by the FRA and the Departments of Transportation of Massachusetts, Vermont, and New Hampshire. The study's first phase, which focuses on ridership forecasts, infrastructure, public participation, and institutional issues, was scheduled for completion in September 2002. Ridership forecasts for the 329-mile portion of the designated corridor from Boston, MA to Montreal, PQ, Canada, predict that nearly 684,000 riders would use a 5:45 hour service between Boston and Montreal.

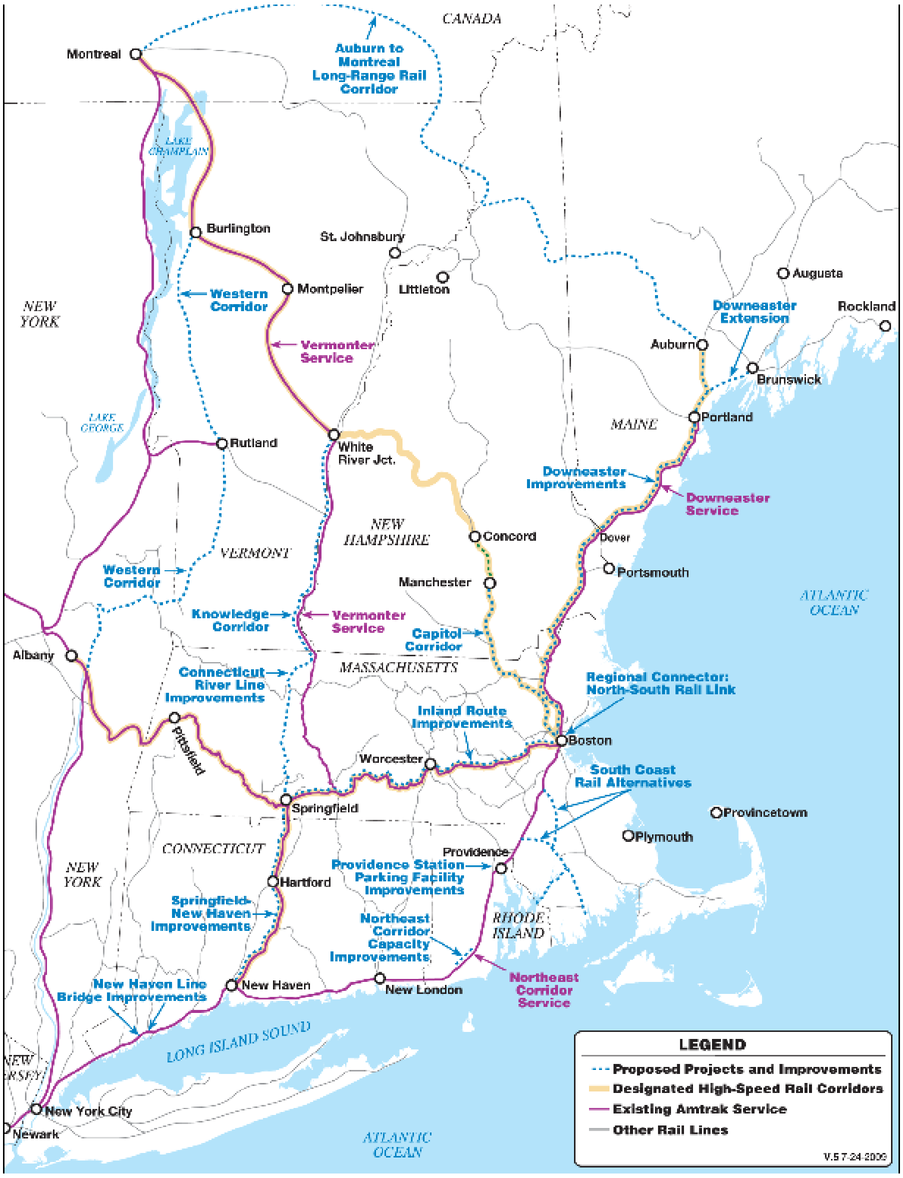

Figure 34. Northern New England Corridor Network (Source: [27])

Project's Goals/Scope: As one of the newest designed HSR corridors, few data has been stated on the scope of this project. The following Table 4 summarizes the top speed and travel time goals.

City Linkages – Federally Designated	Distance (miles)	Top Speed Goal (mph)	Travel Time (Hours)
Boston, MA – Montreal, Canada	339	110	4:31
Boston, MA – Portland,MN – Auburn, MN	150	110	n/a

Table 4. Northern New England Corridor Top Speeds and Travel Times Goal (Source: [27])

Actual Status: The corridor currently includes routes from Boston to (a) Portland, Maine; (b) Montreal, Canada; and (c) Albany, New York, via Springfield, Massachusetts, with an extension from Springfield to New Haven, Connecticut. Frequent passenger service currently links Boston with Portland, and New Haven with Springfield. Less-frequent service connects Boston with Springfield and Albany; there are no passenger trains today between Boston and Montreal. Current speeds on the section from Boston to Portland (which began being serviced by Amtrak in December 2001) average only 59 mph. The States of New Hampshire and Maine have worked with the host Pan Am Railways (formerly Guilford Railroad) to upgrade the Boston - Portland line over which Amtrak's Down-easter operates and there have been some studies of the Boston–New Hampshire–Vermont–Montréal spoke.

5.3 Empire Corridor

Corridor Brief Description: As designated in 1998, the Empire Corridor extends 439 miles from New York City through the Hudson Valley to Albany/Rensselaer and west across the spine of New York to Buffalo (see Figure 35).

Figure 35. Empire Corridor Network (Source: [D])

Background: In September 1998, an MOU was signed by the New York State DOT and Amtrak that committed the former to rebuilding several old Turboliners and the latter to track improvements that would allow speeds of up to 125 mph on the section between New York City and Schenectady. The estimated cost of the plan was $185 million, but travel times were expected to be reduced significantly throughout the corridor. In January 2004, Amtrak announced its intention to withdraw, citing delays and increased costs. In the meantime, three Turboliners were delivered to Amtrak; two were placed in regular service until later in 2004, when they were taken out of service as a result of high fuel consumption and excessive costs.

Project's Goals/Scope: In 2005, the New York State Senate established a HSR Task Force to make recommendations to continue the development of HSR throughout the State. Specifically, a major study of the Hudson Line between New York City and Albany recently analyzed the freight and passenger operations on this corridor through 2020. This study identified necessary infrastructure improvements and estimated the cost of those improvements, including those required to increase passenger train speeds up to 125 mph (Table 5).

New York State has run 110 mph passenger rail service on portions of the Albany - New York City stretch of the Empire Corridor route since the 1970s. The improvements along the line that allowed higher speeds were largely financed through the 1974 Rail Bond Act.

City Linkages – Federally Designated	Distance (miles)	Top Speed Goal (mph)	Travel Time (Hours)
New York City, NY – Albany, NY – Buffalo, NY	439	125	n/a

Table 5. Empire Corridor Top Speeds and Travel Times Goal (Source: [28])

Actual Status: Since its 1998 designation, the FHWA and FRA have jointly allocated $3.4 million for grade crossing improvements on this corridor, primarily on the Hudson Line between New York and Albany. In addition, the State has funded infrastructure improvements on the Hudson Line, enabling passenger trains to operate at speeds up to 110 mph over portions of this 141-mile segment of the corridor. Speeds along the rest of the corridor are limited to 90 mph at most, in part because of the shared ROW with the Metropolitan transportation Authority south of Poughkeepsie and with CSX Corporation railroad for most of the corridor between Poughkeepsie and Buffalo. The State has conducted discussions with Metro North, CSX, and others regarding improvement implementations. An update to the State's five year multi-modal program is under review, which will define a set of capital needs to complete these improvements. As a follow-on effort, the State extended this analysis from Albany to Buffalo with a study to develop an Empire Corridor West Railroad Transportation plan.

5.4 Keystone Corridor

Corridor Brief Description: Consisting of 349 miles, the Keystone Corridor shown in Figure 36, was designated as a federal HSR corridor in December 1998, and it consists of two very different segments: Harrisburg - Philadelphia and Harrisburg - Pittsburgh.

Figure 36. Keystone Corridor Network (Source: [T])

Background: The initial designation linked Philadelphia and Harrisburg, with an extension to Pittsburgh approved by the U.S. DOT in 2000. In November 1999, Amtrak and the State of Pennsylvania entered into an MOU and announced a joint $140 million infrastructure and equipment upgrade program on the Philadelphia–Harrisburg segment of the line to reduce trip times to 90 minutes by 2004, enhance stations, and improve reliability. In October 2003, Governor Rendell announced another $3 million for passenger rail service between Harrisburg and Philadelphia as part of a $125 million capital budget aimed at improving public transportation.

Project's Goals/Scope: The keystone Corridor is another example of an incremental HSR project within one state. The two existing segments of the corridor have different characteristics as described in the next lines. As shown in Table 6, both segments have 110 mph top speed goal.

East of Harrisburg: Sharing some of the operating characteristics of the NEC main line, the Amtrak-owned and -operated Philadelphia - Harrisburg segment (104 miles) is a mature passenger corridor, with frequent intercity trains (14 round trips per average workday, most of which operate on the NEC beyond Philadelphia to New York) and commuter trains for part of the route near Philadelphia. This line has multiple tracks, full electrification, and almost complete grade separation from the highway grid. The remaining three public highway grade crossings on the Philadelphia - Harrisburg segment are being eliminated with current projects. Amtrak is planning additional improvements. Speed on the line is now up to 110 mph. Station improvements and new construction are being pursued at Lancaster and Elizabethtown.

West of Harrisburg: In contrast with Amtrak's portion of the Keystone Corridor, the segment between Harrisburg and Pittsburgh is a heavy-duty freight railroad, owned and operated by Norfolk Southern (NS), with only one passenger train round trip per day, the Pennsylvanian (New York - Pittsburgh), over its mountainous topography. A 2005 NS study suggested that significant infrastructure improvements would be needed to smoothly integrate additional passenger trains with the dense and growing in freight traffic.

City Linkages – Federally Designated	Distance (miles)	Top Speed Goal (mph)	Travel Time (Hours)
Philadelphia, NJ – Pittsburgh, PA	349	110	5:25

Table 6. Keystone Corridor Top Speeds and Travel Times Goal (Source: [T])

Actual Status: Work continues on the line, although more slowly than anticipated. The remaining three public highway grade crossings on the Harrisburg - Philadelphia segment are being eliminated with current projects. Amtrak is planning additional improvements, including the installation of the Positive Train Control (PTC) technology in use on the NEC. Efforts continue on this line, although it appears to have some difficulties similar to the Empire Corridor in terms of Amtrak's role.

5.5 Southeast Corridor

Corridor Brief Description: Designated as a federal corridor in October 1992, the initial Southeast Corridor linked Washington, D.C., to Richmond, Virginia. In 1995, an extension was approved to Hampton Roads, Virginia, with additional extensions approved in December 1998 and October 2000. The current corridor links Washington, D.C., with five states and the Gulf Coast Corridor (through Atlanta) in the following segments shown in Figure 37:

- Washington, D.C.–Richmond, VA
- Richmond, VA–Hampton Roads, VA
- Richmond, VA–Raleigh, NC–Greensboro, NC–Charlotte, NC
- Raleigh, NC–Columbia, SC–Savannah, GA–Jacksonville, FL
- Atlanta, GA–Macon, GA
- Charlotte, NC–Atlanta, GA

Southeastern HSR includes the federally designated corridor, but extends the links to include the segment to Birmingham, Alabama, covered by the Gulf Coast federally designated corridor and an additional segment to Chattanooga and Nashville, Tennessee.

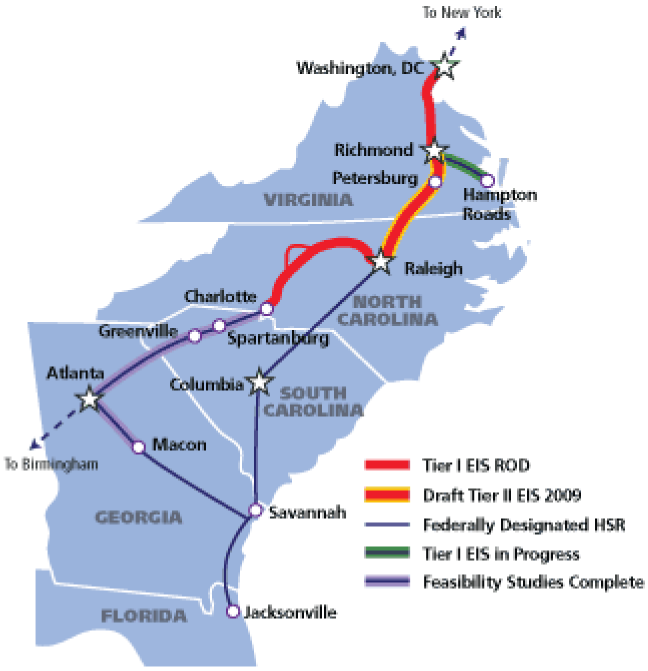

Figure 37. Southeast Corridor Network (Source: [V])

Background: A report issued in 1997 by the U.S. DOT identified the Southeast Corridor as the most economically viable of all the proposed HSR projects. One year later, the Virginia Department of Rail and Public Transport, North Carolina's DOT, the FRA, and the FHWA signed an MOU to jointly develop environmental documentation related to implementing HSR on the portions of the corridor in Virginia and North Carolina. A Tier I EIS followed in 1999, focused on the Washington, D.C.- Charlotte segment of the corridor. The Tier I EIS was completed in 2002 and a Record of Decision on the proposed route was issued by the FRA and FHWA, allowing the Tier II EIS to begin. The proposed date of completion was 2004.

Project's Goals/Scope: North Carolina, Virginia, South Carolina, and Georgia have been collaborating to implement HSR in the designated Southeast Corridor. The most intensive effort has thus far gone to the originally designated Washington - Richmond - Charlotte segment for which the FRA and Amtrak have developed detailed transportation plans, which the Commonwealth and CSX Transportation have begun to implement on an incremental basis. Plans show that with up to 110 mph speeds, trip times of two hours (Washington - Richmond) and four and one-half hours (Richmond-Charlotte) would be feasible (see Table 7). Two States have created the Virginia-North Carolina Interstate HSR Compact to provide authority and legislative oversight for the implementation of HSR. Georgia just completed a planning study for Charlotte to Atlanta improvements.

City Linkages – Federally Designated	Distance (miles)	Top Speed Goal (mph)	Travel Time (Hours)
Washington, - Richmond,	118	110	2:10
Richmond, - Hampton Roads,	74	110	1:30
Richmond, Raleigh, Greensboro – Charlotte	338	110	4:25
Charlotte – Atlanta	260	110	n/a
Atlanta – Macon	84	110	n/a

Table 7. Southeast Corridor Top Speeds and Travel Times Goal (Source: [V])

Actual Status: Virginia and North Carolina, together with the FHWA and FRA, in October 2002 completed a Tier I EIS and selected a route from Washington, DC to Charlotte, NC employing the abandoned CSX "S" line between Petersburg, VA, and Norlina, NC. A Tier II EIS is being prepared with FRA for the Richmond, VA to Raleigh, NC section of the corridor. A Record of Decision is anticipated in late 2010.

5.6 Florida Corridor

Corridor Brief's Description: The designated Florida Corridor links Tampa Bay, Orlando, Miami, and intermediate points. The Corridor travels north from Miami through West Broward and West Palm Beach before turning southwest at Orlando to Lakeland and Tampa. The Florida Corridor plans to connect Orlando to Tampa at the beginning (Phase 1), with a later extension to St. Petersburg (Phase 2). After that, there is a proposed route to extend the network to Miami, Fort Myers, Jacksonville, Tallahassee and Pensacola (see Figure 38).

Figure 38. Florida Corridor Network (Source: [W])

Background: Chapter 4 has a discussion of the different attempts to achieve a HSR system in the history of the State of Florida. Florida voters authorized funding for the HSR system by a 2000 referendum but repealed by 64% of voters in a 2004 referendum. Some have argued that the wording of Bush government on the 2004 referendum was misleading, and some may have assumed it was the same as the 2000 referendum and voted the opposite of what they meant to vote. Although the amendment has been repealed, the Florida HSR Authority Act is still in effect pending any action that the Florida Legislature may choose to take in the future. To date, the Florida Legislature hasn't appropriated any more funds.

Project's Goals/Scope: The State of Florida has attempted more than once to develop the entire designated corridor (or portions of it) to support very high-speed (over 150 mph) intercity rail service, but has not succeeded thus far in doing so. Tampa to Orlando HSR was most recently advanced as the first leg of a statewide system at an approximate cost of $2.5 billion on a dedicated infrastructure using the Interstate 4 ROW. The peak speed would be 150 mph with adoption of the electric power option. A competitive procurement for this system was put on hold in 2005. Since then, Florida has concentrated its study efforts on incremental HSR planning with top speed goals shown in the next Table 8. On October 2004, the authority voted to prefer the consortium of Fluor Corp. and Bombardier Transportation to build and operate the system, using Bombardier's JetTrain technology.

City Linkages – Federally Designated	Distance (miles)	Top Speed Goal (mph)	Travel Time (Hours)
Orlando, FL – Tampa, FL	92	>120	1:00
Miami, FL – Orlando, FL	282	110	2:57

Table 8. Florida Corridor Top Speeds and Travel Times Goal (Source: [W])

Actual Status: Despite the denial of funding due to the referendum passed in 2004, the Florida HSR Authority has completed the Final Environmental Impact Statement for the Tampa to Orlando project segment, and the next step will be issuance of a Record of Decision by the FRA.

5.7 Gulf Coast Corridor

Corridor Brief's Description: Formally designated as a federal HSR corridor in November 1998, with extensions approved in October 2000, the Gulf Coast Corridor covers 1,022 miles and uses New Orleans as its hub, with three spokes reaching Houston, Texas, Mobile and Birmingham, Alabama and Atlanta, Georgia (see Figure 39). At Atlanta, the Gulf Coast Corridor would connect with the Southeast Corridor to Charlotte, Richmond, Washington, and NEC points.

Figure 39. Gulf Coast Corridor Network (Source: [T])

Background: The lead for planning the corridor is the Southern Rapid Rail Transportation Commission (SRRTC), which includes representatives from Louisiana, Mississippi, and Alabama. In September 2002, the SRRTC was awarded a cooperative agreement by the FRA for Phase I of the Deep South HSR Corridor Study. In Phase I, it will identify institutional issues, make service projections, gather information, and develop a rail operations plan. A specific strategy for implementation will form the basis for Phase II. Because funding for the study was scheduled to last through September 2004, it is likely that the study is not yet completed. According to the FRA, there are physical constraints along the CSX lines between New Orleans and Mobile that might prevent HSR for much of this distance.

Project's Goals/Scope: The States are aiming to upgrade existing rail lines to 110 mph service (see Table 9) and are preparing a strategic plan. The goal is to run HSR at speeds of 110 mph. Louisiana received a $1 million earmark in Fiscal Year 1999 and $1.85 million was provided under TEA-21 for elimination of at-grade crossings.

City Linkages – Federally Designated	Distance (miles)	Top Speed Goal (mph)	Travel Time (Hours)
Houston, TX – New Orleans, LA	362	110	n/a
Mobile, FL – New Orleans, LA	139	110	n/a
New Orleans, LA – Atlanta, GA	521	110	n/a

Table 9. Gulf Coast Corridor Top Speeds and Travel Times Goal (Source: [T])

Actual Status: At present, no corridor-type intercity rail service operates in this corridor, although Louisiana has been working with Amtrak and the Kansas City Southern to initiate a commuter service between New Orleans and Baton Rouge and a New Orleans gateway rail improvement project. The FRA has made study grants to the Southern HSR Commission (SHSRC), formerly known as the Southern Rapid Rail Transit Commission), which comprises appointees of the three member states (Louisiana, Mississippi and Alabama).

5.8 South Central Corridor

Corridor Brief's Description: As designated in 2000, the South Central Corridor consists of a hub at Dallas-Fort Worth, Texas, with spokes extending to Oklahoma City and Tulsa to the north, Texarkana, Texas/Arkansas, Little Rock, Arkansas, to the east and northeast, and Austin and San Antonio to the southwest (see Figure 40). The entire system covers 994 miles.

Figure 40. South Central Corridor Network (Source: [T])

Background: Discussed in the previous chapter, efforts for HSR in Texas began in 1987 when the Texas Legislature directed the Texas Turnpike Authority to study the feasibility of HSR in the Texas Triangle (Dallas – Houston - San Antonio). The South Central Corridor that was designated a federal corridor in October 2000 it is not the same project that terminated in 1993 because of financial disagreements between the State and the private Texas TGV Consortium.

Project's Goals/Scope: Using discretionary Next Generation HSR Program technology demonstration funding, FRA together with the Oklahoma DOT performed precision aerial digital mapping of the developing HSR corridor between Dallas - Fort Worth, Oklahoma City, and Tulsa. At present, Amtrak serves these markets with a single long-distance train (the Texas Eagle) and the Oklahoma-sponsored Fort Work-Oklahoma City Heartland Flyer train. As shown in Table 10, there is no information about speeds and travel times goal yet.

City Linkages – Federally Designated	Distance (miles)	Top Speed Goal (mph)	Travel Time (Hours)
Tulsa, OK – Dallas/Fort Worth, TX	322	n/a	n/a
Little Rock, AR – Dallas/Fort Worth, TX – San Antonio, TX	672	n/a	n/a

Table 10. South Central Corridor Top Speeds and Travel Times Goal (Source: [T])

Actual Status: Currently, the Texas DOT (TxDOT) is conducting an analysis of its statewide railroad network, which will support TxDOT's plan to connect the state's population centers on designated freight, intercity passenger, and HSR corridors. Texas has requested federal funding to perform an initial feasibility study of high-speed service on the Texas portion of the corridor. However, all eligible funding for these activities is earmarked for other projects in the FRA budget. The state has also begun a study to identify the risk levels at grade crossings along the corridor. Since 2000, the FHWA and FRA have jointly allocated $2.558 million for grade crossing improvements on the corridor in all three states. Nothing appears to have moved forward in this corridor.

5.9 California Corridor

Corridor Brief's Description: The development of a new electrically powered HSR system would serve major population centers from San Francisco and Sacramento to Los Angeles and San Diego. Through these connections it will involve other major cities like Merced, Bakersfield and Anaheim. In the next page, Figure 41 shows the entire California corridor with the only two diesel intercity trains that are included in the project.

Figure 41. California Corridor Network (Source: [X])

Background: Since the 1980s, the State of California and Amtrak have made significant investments in equipment and facilities to develop three passenger rail corridor services: the San Joaquins (Bay Area/Sacramento–Central Valley, with bus connections to L.A.); Capitols (San Jose – Oaklan – Sacramento - Auburn); and Pacific Surfliners (San Luis Obispo - L.A.- San Diego). In 2008, total intercity ridership on California's State-supported corridor trains–at 5.5 million–accounted for one fifth of Amtrak's passenger-trips nationwide. A strategic plan was prepared for improvement of the Pacific Surfliner Corridor from Los Angles to San Diego eventually to speeds of up to 110 mph. On July 2, 2009, U.S. transportation Secretary Ray LaHood announced extension of the California HSR corridor to Las Vegas, Nevada.

Commercial Feasibility Study forecasts that by the year 2020, rail passenger service with 110 mph top speeds in California would generate more ridership than the entire NEC did in 1993; and a new HSR system would triple or quadruple Amtrak's NEC 1993 traffic benchmark, according to FRA's projections.

Project's Goals/Scope: California is pursuing continued improvements to existing passenger rail corridor services and a new HSR system. Such a system would operate at sustained speeds of 220 mph over much of its length as shown in Table 11, except for access to certain urban areas (e.g. San Jose - San Francisco). Intercity travelers (trips between metropolitan regions) along with longer distance commuters would enjoy the benefits of a system designed to connect with existing rail, air and highway systems. The 800 miles system would be electrified, double tracked and completely grade-separated. Phase 1 involves San Francisco to Los Angeles and Anaheim and the cost is approximately $32.0 billion.

City Linkages – Federally Designated	Distance (miles)	Top Speed Goal (mph)	Travel Time (Hours)
San Francisco, CA – Los Angeles, CA	432	220	2:38
Sacramento, CA – Los Angeles, CA	412	220	2:17
San Diego, CA – Los Angeles, CA	167	220	1:18

Table 11. California Corridor Top Speeds and Travel Times Goal (Source: [X])

Actual Status: The HSR Programmatic Tier 1 EIS is complete. Site-specific EIS and preliminary engineering is underway for Phase 1. Also, a Tier I EIS has also been completed for conventional improvements to the Los Angeles to San Diego Pacific Surfliner corridor. An EIS and preliminary engineering are in an advanced stage for run-through tracks at L.A. Union Station to enhance Pacific Surfliner service.

5.10 Pacific Northwest Corridor

Corridor Brief's Description: The line would run approximately 466 miles and link Portland and Seattle with Vancouver and Eugene as shown in next Figure 42.

Figure 42. Pacific Northwest Corridor Network (Source: [T])

Background: As discussed in a previous chapter together with the Florida and Texas cases, this 466-mile route houses Amtrak corridor and long-distance trains, Sounder commuter services in the Seattle region, and the freight trains of the owning railroad companies (Union Pacific and BNSF). Amtrak's Cascades service links Eugene and Portland, Oregon with Tacoma and Seattle, Washington and Vancouver, British Columbia. Since its 1992 designation, the FHWA and FRA have jointly allocated $8.395 million for grade crossing improvements on this corridor, primarily between Portland and Seattle. Between 1994 and 2007, Washington (with participation from Oregon) invested a total of some $700 million from all sources to upgrade track and signal systems, renovate stations, and purchase trains to operate on the Pacific Northwest Corridor.

Project's Goals/Scope: Incremental improvements are planned to eventually support 110 mph service with greater frequencies on the Portland – Seattle - Vancouver portion of the corridor (see Table 12). The project's sponsors plan to install a new signal and monitoring system using global positioning satellites, renovate stations and improve grade crossings along the current rail line between these cities. Also, new sidings and track will be added in some places to add capacity to the line, which will serve freight, commuter, and HSR.

City Linkages – Federally Designated	Distance (miles)	Top Speed Goal (mph)	Travel Time (Hours)
Eugene, OR – Seattle, WA	310	110	2:30
Seattle, WA – Vancouver, BC	156	110	2:50

Table 12. Pacific Northwest Corridor Top Speeds and Travel Times Goal (Source: [T])

Actual Status: The State of Washington and Amtrak have purchased three Talgo trains capable of traveling 125 mph to meet the growing demand. However, in the Pacific Northwest corridor they are limited to 79 mph because of track conditions. These three new Talgo trains replace the leased ones and will reduce the travel times along the route. Also, WSDOT and the Oregon DOT are currently preparing an environmental impact statement and a 20-year investment plan for the corridor. In November 2008, voters in the State of Washington passed a ballot measure called “Sound Transit 2” which provided $17.9 billion for transit and commuter rail investment in the Puget Sound region. Environmental documents have been prepared for the Vancouver Rail Bypass and Pt. Defiance Bypass projects. The project's sponsors have not announced any schedule for the start of HSR service.

6. NETWORK ANALYSIS

6.1 Levels of Demand

Before starting a HSR project and see if it will be viable, it is necessary to identify the factors that will influence people's decision on which method of transport to use. Demand for travel in any HSR corridor is the result of four key sources:

Existing demand for travel in the corridor: The existing travel demand in the corridor is composed of current demand for air, auto, bus, and rail modes.

Amount of demand currently suppressed due to travel conditions in the existing corridor: In heavily congested corridors actual demand often outstrips the recorded demand as users choose not to make a trip rather than face the congestion in the corridor. The suppressed demand should be based on the level of congestion in the corridor and the level of growth in alternative transportation modes over the past couple of years. As a corridor becomes congested, growth slows which can suggest that demand is being suppressed.

Amount of demand generated through the creation of an alternative mode choice: Historically, when a new method of transportation is offered to users, a certain level of trips that would have not been taken without the new option will occur. These trips are called induced trips and are new to the system. For instance, if a new high speed line is operating between two major cities individuals now have the choice to take a trip on the rail line that they might not have taken prior to its existence.

Amount of demand generated through background growth along the corridor: The amount of demand generated through background growth is a combination of population, employment, GDP, and other socioeconomic factors in the corridor and at the station locations **[29]**.

During the past few years in the U.S., high levels of population, expected population growth along a corridor and strong business as well as cultural ties between cities have been identified as factors that can lead to higher demand for intercity travel. In some corridors, riders are expected to come from business travelers and commuters due to the strong economic ties between cities along the corridor; while in other corridors, a larger number of tourists and leisure travelers comprise the expected riders.

In Japan, the importance of connecting several high-population areas along a corridor was and still is a key factor in the high number of riders on their system, and to effectively serve several travel markets, including commuters and travelers from cities along the corridor. The corridor between Tokyo and Osaka in Japan is unique in that it is one of the most populous regions in the world, with multiple urban areas of several million inhabitants located along the corridor. This corridor attracts the highest number of riders of any HSR line in the world—over 150 million annually **[19]**. In other foreign corridors, however, population densities are not as high, but there are indications that HSR revenues in these areas are sufficient to cover ongoing operating costs, although not necessarily sufficient to recoup the initial investment in the line. Some, but not all of the corridors under development in the U.S. today have population levels similar to corridors in other foreign countries (see Figures 43 and 44).

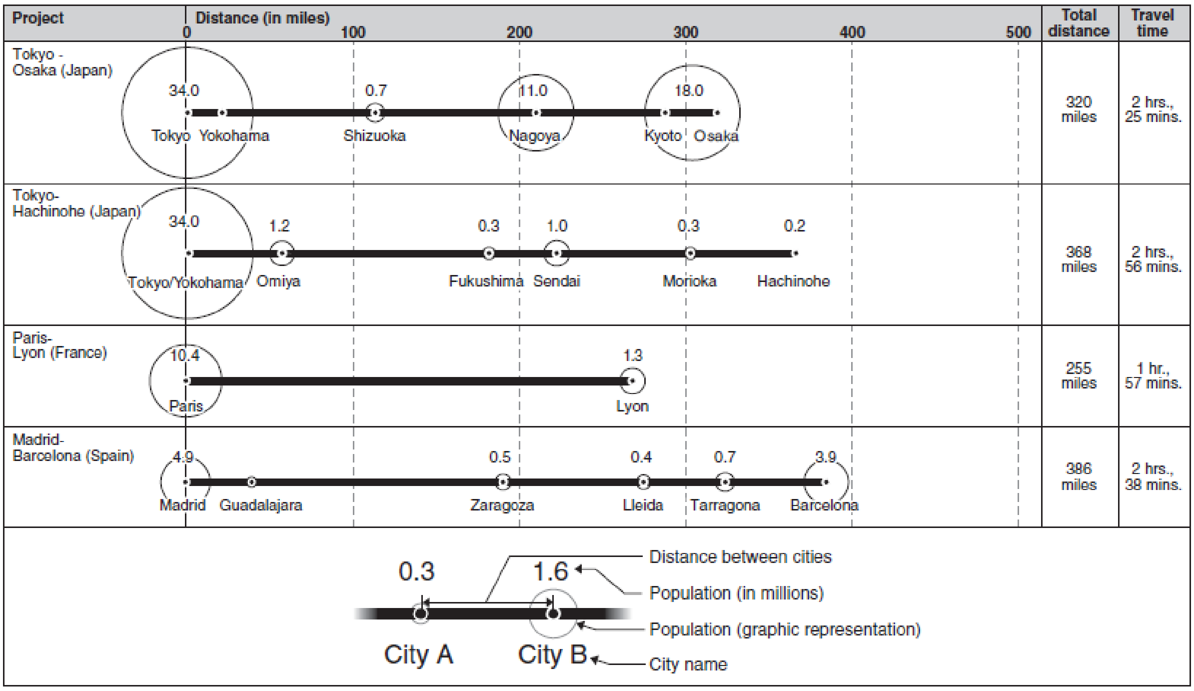

Figure 43. Population of Cities Along some Selected Foreign HSR Lines (Source:[Y])

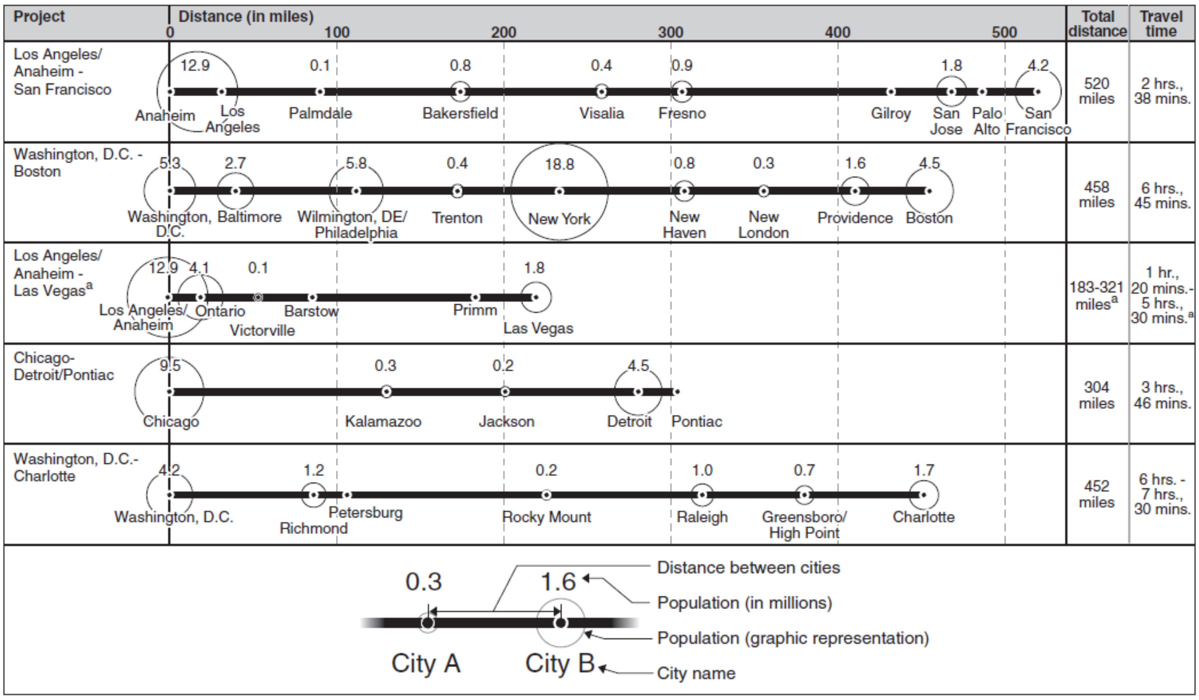

Figure 44. Population of Cities Along some Current and Proposed HSR Lines in the US (Source:[Y])

HSR also has more potential to attract riders in corridors experiencing heavy travel on existing modes of transportation (i.e., conventional rail, air, and highways - including automobile and bus) because of congestion and constraints on the capacity of existing transportation systems. These situations lead to demand for an additional transportation alternative, or demand for expansion or improvements to existing modes that need to be time and price competitive with the alternatives. Also needed are favorable service characteristics related to frequency, reliability, and safety.

In France, Japan, and Spain the high ridership is in most part attributed to the reliability and safety of their HSR lines, relative to alternative modes of transportation. In Japan, the average delay between Tokyo and Osaka was 30 seconds per train in 2007. This average delay throughout the year includes delays caused by typhoons, earthquakes, snowfall, heavy rain, and other natural disasters. Beginning in March 2009, up to 13 trains per hour will leave Tokyo for Osaka on any given business day. In Spain and France, delays are also minimal, although service is less frequent. Between 20 and 36 one-way trains run daily on the Madrid to Seville, Madrid to Barcelona, and Paris to Lyon lines. To ensure on-time performance in Europe and Japan, train operators are given strong incentives to stay on-time, including passengers receiving a full ticket price refund in Spain if the train is delayed more than 5 minutes, and driver pay deductions in Japan if the train is delayed more than 1 minute due to human error.

The FRA has found that HSR tends to be most time-competitive at distances of up to 500 miles in length. Generally, lines significantly shorter than 100 miles do not compete well with the travel time and convenience of automobile travel, and lines longer than 500 miles are unable to overcome the speed advantage of air travel **[30]**.

Existing HSR lines in Japan tend to be most time-competitive and attain the highest relative levels of service in corridors of roughly similar distances. In and of itself, a total travel time advantage does not guarantee that a mode is viable, nor superior in those terms to some alternative. In all countries where the HSR system has been established, there has been considerable improvement in travel time between several major metropolitan areas (Figure 45), on average a 50% reduction. In many cases like for example in France on the Paris - Lyon line on the Paris - Marseille axis, the drop in travel time has placed new areas within commuting range.

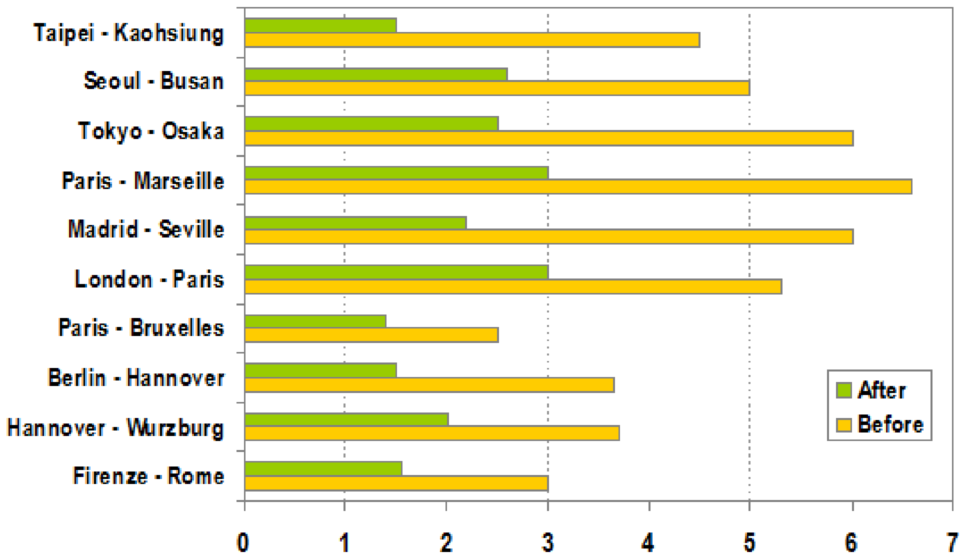

Figure 45. Travel Times before and after the Introduction of a HSR Service (time in hours) (Source:[F])

Between 100 and 500 miles, HSR can often overcome air travel's speed advantage because of reductions in access and waiting times. Air travel requires time to get to the airport, which can often be located a significant distance from a city center, as well as time related to checking baggage, getting through security, waiting at the terminal, queuing for takeoff, and waiting for baggage upon arrival at a destination. By contrast, HSR service is usually designed to go from city center to city center, which generally allows for reduced access times for most travelers. Some travelers will have destinations or starting points outside of city centers in closer proximity to airports, thus, potentially minimizing or eliminating the access time advantage of HSR where HSR service does not connect to airports or other locations preferred by travelers. HSR also generally has less security and waiting time than airports. For many foreign HSR lines like in Spain, there is no formal security comparable to that of airport security, and travelers can arrive at a station just a few minutes prior to departure **[31]**.

In France, Japan, Spain, and elsewhere, HSR has been shown to be time-competitive with air travel and has relieved capacity constraints at airports. For example, HSR in Japan has resulted in eliminating one air route (Tokyo - Nagoya), while several others have lost significant market share to HSR. With the introduction of the Madrid - Barcelona HSR line in February 2008, air travel between the two cities has dropped an estimated 30% (from 5.0 million to 3.5 million air passengers), while HSR riders increased markedly. In France, HSR has captured 90% of the Paris - Lyon air -rail market, and Air France estimates that for HSR trips of between 2 and 3 hours, HSR is likely to capture about 80% of the air-rail market over time. By displacing shorter distance air travel, HSR has freed up considerable airport capacity in those cities for other longer distance flights. However, because HSR becomes a new competitor with short-distance air travel, airlines have in some cases actively opposed its development. In the U.S., most of speed the rail projects will connect metropolitan areas with anticipated capacity constraints at nearby airports (see next Figure 46).

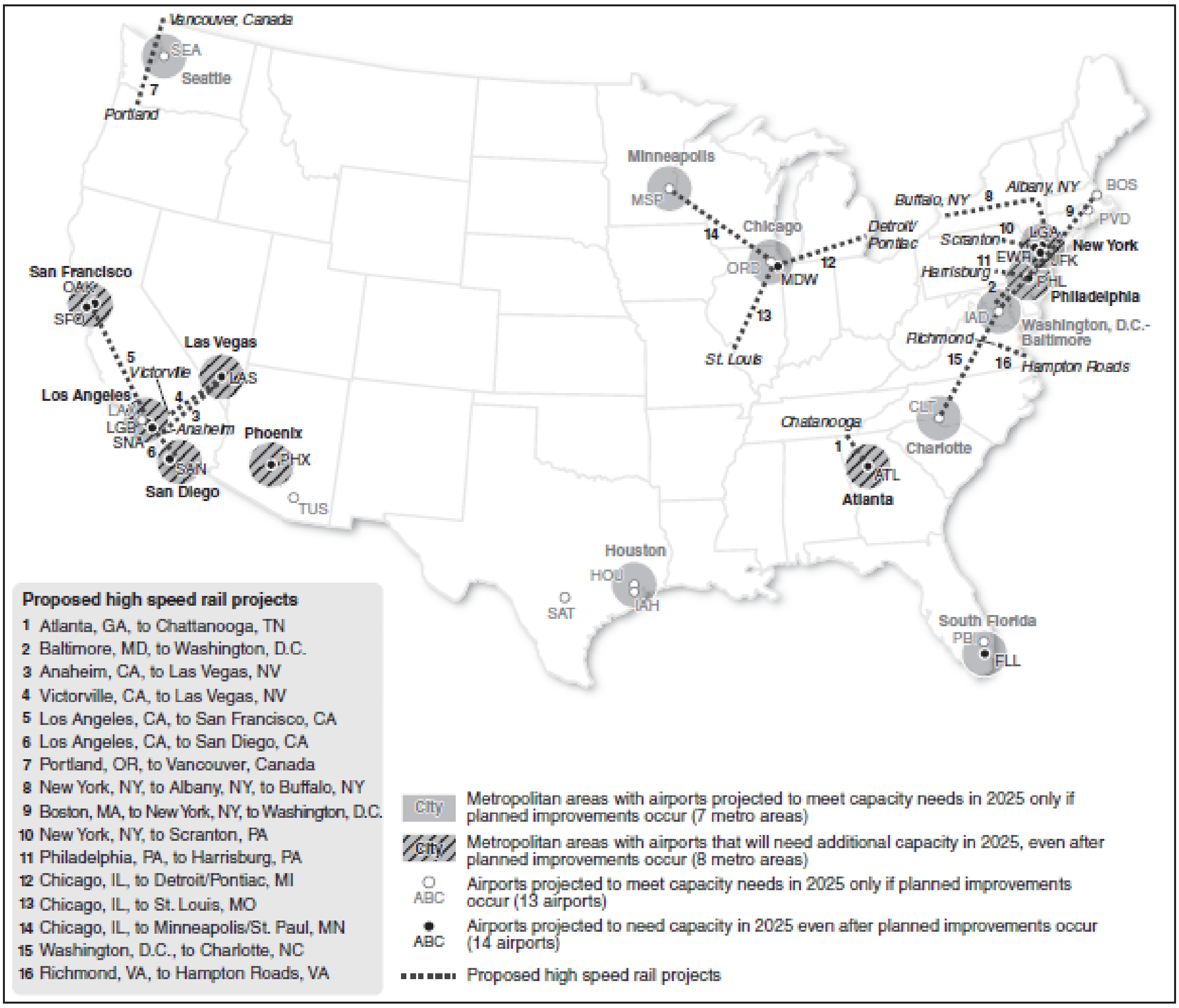

Figure 46. Future Airport Capacity, by 2025, and Selected HSR Proposals in the U.S.(Source: [Z])

While HSR will generally have superior travel times compared with automobile or bus travel for trips greater than 100 miles (depending on the service) it is difficult for a HSR service to compete with the low price of bus travel and convenience of automobile travel. HSR is therefore not likely to attract a sufficient number of these travelers to have a significant effect on highway congestion and capacity in a corridor. According to a study on HSR ridership forecasting, intercity bus travel is limited and bus riders care more about price than about time. As a result, the extent that a new HSR line provides time savings at a somewhat higher cost, the contribution of bus travel to a new HSR line will be insignificant **[32]**. However, this result depends on how the HSR service is priced. If the HSR service is publicly funded, then a legitimate public policy question arises regarding fare-setting (i.e., whether HSR fares should be set to maximize revenues or to attract higher numbers of riders from other modes). The study also contends that those who travel by car tend to care more about price and convenience (e.g., leaving when they choose, bringing additional passengers or cargo at no extra cost) and less about trip time.

The effect on highway congestion of diverting automobile travelers to HSR will vary based on the specific locations and times. For example, if HSR can divert travelers from making an intercity trip through a congested highway at peak times, then it may have a noticeable effect on traffic. Over the long term, however, whatever trips are diverted on a congested corridor to another mode of travel are likely to be at least partially replaced by other trips, since the reduced congestion from diversion makes it easier to travel, a phenomenon known as “induced demand” **[29]**. Nonetheless, given the great number of trips by car, the diversion of a small percentage of automobile travelers to HSR could have a significant impact on the number of HSR riders, and result in benefits arising from increased capacity in the transportation system and thus more trips being carried. For example, in Japan, a survey on a recently developed HSR line showed that 21% of riders on a new HSR line diverted from the automobile mode. Similarly, in studies conducted for California’s proposed statewide HSR system, over 40% of forecasted riders are projected to be diverted from automobile travelers, however the HSR line will only reduce automobile travel by an estimated 7%.

We also have to take into account that in the U.S., automobile travel tends to be significantly cheaper than in other countries resulting from lower gas prices, taxes and near exemption of tolls on intercity roads.

6.2 Connectivity

Another factor that affects the competitiveness of HSR relative to alternative intercity transportation modes is the extent to which it is part of an integrated transportation system and adequate transit services are available at the destination points for travelers. It has to be pointed out that in France, Japan, and Spain there is a great importance of strong transit access to, from and within downtown areas to attract riders to HSR. European HSR stations are designed to be integrated with the urban transportation network, including subways, conventional rail, and local buses. In France, HSR connects with airports. In Spain, however, HSR generally does not connect to airports. Japanese stations are also integrated with other transit options, although HSR in Japan as in Spain also does not connect to airports. In these countries, rail travelers will generally not require an automobile at the end of the rail line to get to their final destination in metropolitan areas. Most urban transit systems in the U.S. are not as well developed as compared with systems in France or Japan. For some proposed lines in the U.S., travelers may need access to an automobile at their destination, potentially making travel by HSR a less attractive option for those riders. However, a number of domestic project sponsors recognize the importance associated with designing and constructing their HSR systems to take advantage of existing transit connections and planned improvements. For example, the proposed Maglev line between Las Vegas, Nevada, and Anaheim, California, is being designed to connect to a new intermodal transit terminal being built in Anaheim. In addition, the bond measure that was recently passed in California to help fund HSR development allocates $950 million for funding toward connecting rail transit services.

6.3 Public Benefits

While all U.S. sponsors cite a variety of public benefits that would flow from their projects, such as congestion relief or environmental benefits, the extent to which benefits have been quantified and valued vary for each project. Several types of public benefits that are significant in determining the economic viability of proposed HSR lines are the following:

Travel time savings: Travelers using alternative modes may experience travel time savings as a result of reduced highway traffic and airport use by travelers shifting to HSR. Rail is a cost-effective means for serving transportation needs in congested intercity corridors. In many cases, modest investment on existing ROW can result in HSR and intercity passenger rail service with highly competitive trip times, while also providing ancillary benefits to energy-efficient freight rail service.

Environmental benefits: Environmental benefits could result from reducing pollution and carbon dioxide emissions, provided that the rail service reduces congestion on highways or at airports and makes use of fuel-efficient technology. Rail is already among the cleanest and most energy-efficient of all passenger transportation modes. A HSR service using diesel locomotives would provide less environmental benefit than a service that is electrified. However, creating a future rail network using new clean diesel or electric power could further enhance HSR's advantages. According to one recent study, implementation of pending plans for the federally designated HSR corridors could result in an annual reduction of 6 billion pounds of CO_2 (2.7 $MMTCO_2$) **[33]**.

Traffic safety: Increased rail traffic safety directly reduces the number of traffic accidents by reducing congestion on highways. Trains also tend to have fewer accidents than on highways. For instance, in Japan, the Tokaido Shinkansen trains have operated without a derailment or collision since the inception of operations in 1964.

Economic development, land use and employment: Providing a robust rail network can help serve the needs of national and regional commerce in a cost-effective, resource-efficient manner, by offering travelers convenient access to economic centers. Implementing a system that encourages relocation of households and businesses, in the cities where passenger rail stations are located, a potential outcome could include population growth and business presence by increasing retail sales, rental income, and property values. Rail transport has generally been associated with "smart growth" because it can foster higher-density development when compared to development associated with highways and airports. Rail is uniquely capable of providing both high-speed intercity systems as well as its own efficient local access and egress system.

Quantifying public benefits can be difficult and the level of value and importance of these benefits can be subject to disagreement. Furthermore, there are currently multiple federal guidelines in the U.S. for valuing public benefits, yet none have been designated for use in analyzing proposed HSR projects. For example, HSR service that reduces congestion on highways or at airports and makes use of fuel-efficient technology may provide an environmental benefit (i.e., reduced pollution and greenhouse gas emissions). However, the value to assign to the reduction of pollution and greenhouse gas reductions is difficult to determine, since there is no current market for pollution reduction in the U.S.. Thus, the valuation of pollution reduction (defined as the public's willingness to pay) is generally left to economists to estimate by indirect methods. The valuation of greenhouse gas reductions entails additional considerations that are based on uncertain future benefits. Other intangible benefits, such as economic development impacts, are also difficult to estimate and are subject to disagreement.

In Japan, although they previously calculated regional economic development benefits and included them in HSR decision making, they abandoned the practice because it was too difficult to isolate the impacts and because they believe that benefits accrued through revenues and passenger benefits alone are sufficient to meet their criteria for constructing new HSR lines. Moreover, while benefits such as improvements in economic development and employment may represent real benefits for the jurisdictions in which a new HSR service is located, from another jurisdiction's perspective or from a national view they may represent a transfer or relocation of benefits.

Some of the non-monetary benefits that HSR can provide on both a regional and a federal level are the following:

Federal Level: The creation of HSR is in line with the goals of the ARRA program, as it will;

- Spur new job creation within multiple industries including construction and engineering
- Update America's aging transportation infrastructure system
- Reduce the country's dependence on foreign oil by shifting users away from automobile and air travel
- Reduction of environmental impacts associated with the transportation sector

Regional Level: HSR produces a further array of benefits at the regional level such as it will;

- Reduce congestion on local roads, highways and interstates as travelers shift their mode usage from automobile to HSR
- Reduce airport congestion as HSR captures users from short-haul flights. This could reduce the frequency of those flights allowing previously used gate slots to open, and airlines to focus on longer-haul, less environmentally harmful, higher-margin flights.

7. ECONOMIC VIABILITY

Factors affecting the economic viability of HSR lines include (1) expected ridership levels, (2) construction and operating costs, and (3) public benefits (i.e., benefits to non-riders and to the nation as a whole) due, for example, to reduced congestion.

In the previous chapter, discussion has been focused on expected ridership levels by studying the levels of demand in relation with the population density of the corridors and the existing modes of transportation. It can be concluded that rider forecasts and cost estimates are inherently uncertain and subject to some degree of inaccuracy simply because they are trying to predict future circumstances. In the U.S. as well as other countries, HSR tends to attract riders in corridors with high population density, especially where congestion on existing transportation modes prevails. Service characteristics of a HSR line relative to other travel alternatives (such as trip time, frequency of service, reliability, and safety) are also critical factors in determining the economic viability of the projects.

The elements that determine the economic viability of a HSR line are the previous expected demands and its associated revenues and the expected capital and operating expenses. Even if the expected revenues will not cover the expenses, the project may still be considered worthwhile if it provides non-monetary benefits such as reduced congestion on the alternative modes or reduced environmental impacts. These benefits are typically considered in a cost benefit analysis which converts all the project's impacts into monetary figures and determines the final benefit and cost to the public.

7.1 Forecasting HSR Demand and Expenses

As previously explained, understanding the viability of a HSR line requires correctly determining the demand for travel in the corridor. Once the demand is calculated, the percentage of the demand selecting HSR for their travel can be determined using a transportation network model. Transportation network models will base a users' choice of transportation mode to use on tangible elements including cost, reliability, and availability as well as intangible elements such as environmental consciousness, personal preferences, and perceived level of comfort. The percentage of demand selecting HSR is called the rail capture rate. This process is presented in the flowchart on Figure 46.

The rail capture rate and the rail fare can be used to calculate the expected revenue. There will be an optimal rail fare which will establish equilibrium between the highest level of demand and highest level of revenue. This optimal fare can be determined through iterations of the model. Overall, this framework will allow for the calculation of the expected demand and revenue and help to gauge the expected attractiveness of the line to the public.

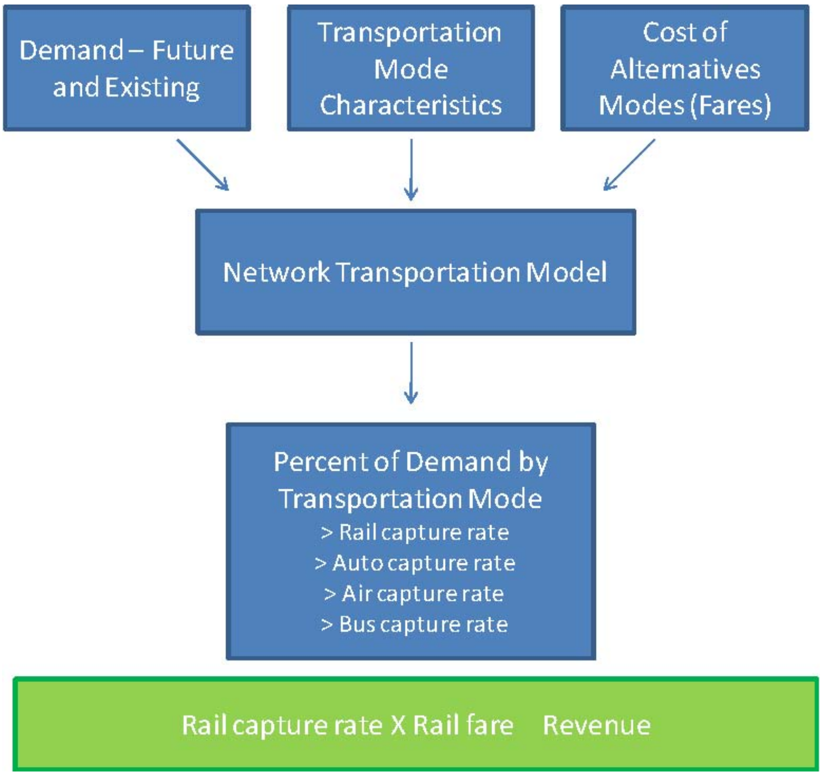

Figure 47. Ridership and Revenue Forecasting Model (Source: [34])

In addition to the expected ridership, it is important to study the expenses to analyze the viability of a HSR project. To do that, it is necessary to separate the costs into two categories: Capital expenditures (Capex) and Operating expenses (Opex). The costs associated with these two categories are discussed below.

• ***Capital Expenditures***: Capex consists of the initial construction costs of the tracks as well as all future costs of repairing or replacing the infrastructure and the rolling stock. Of the types of passenger rail services available, true HSR service is on the highest end of the scale as it operates mainly on dedicated track with grade separated crossings. The passenger rail services by cost levels are shown below on Figure 48.

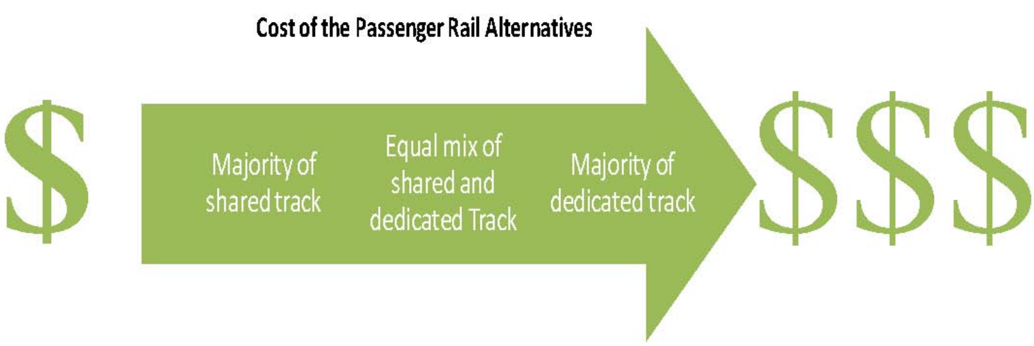

Figure 48. Passenger Rail Services by Cost Levels (Source: [34])

As HSR projects require a significant investment effort, government agencies have historically chosen to make improvements to existing tracks - i.e. converting at grade crossings to grade separate crossings, reducing the curvature at the curves, etc. These improvements are less costly, but the final product is also less competitive with other modes of travel producing a much lower ridership and revenue profile. Corridors where ROW is available for rail purposes and are relatively flat with straight track alignments can help lower costs compared with corridors that require the acquisition of new ROW, substantial tunneling, or bridges **[35]**.

***Operating Expenses**:* Opex includes the costs for preventative maintenance of the tracks and stations and the operation of the train. As the HSR service provided is continuously operated, preventative maintenance of the track occurs during the off peak hours, typically at night, and is generally low scale maintenance. Operation costs of the train include energy, personnel (crew members and administrative staff), onboard service, station operation, traffic control, insurance, and also sales and marketing costs. As HSR Opex is not linked to demand but rather to the operating schedule, the operation cost should be within the same range each year.

To stay within financial or other constraints, project sponsors must typically trade-off some level of ridership to reduce costs. For example, most domestic projects currently under consideration are incremental projects on tracks shared with freight operators, a choice that limits the travel time competitiveness and reliability valued by riders that would be possible on more expensive, dedicated tracks. As mentioned earlier, research on ridership and cost forecasts for transportation projects has shown that such forecasts are often significantly optimistic and different ridership forecasting methods may yield diverse, and therefore uncertain, results **[36]**.

In foreign countries, the ability to achieve the time-competitiveness, frequency, reliability, and safety previously described is attributed to operating on dedicated track and having no at-grade highway or other crossings. These systems though, cost billions of dollars to construct, although construction cost per mile vary substantially (see Table 13 on the next page). In Spain, construction costs have ranged from $37 million to $53 million per mile, the latter heavily influenced by the construction of two tunnels. In Japan, construction costs are typically higher because of antiseismic safeguards, high land costs, and the number of bridges and tunnels needed to accommodate straight-and level-track through Japan’s mountainous terrain.

The cost figures for different projects are not strictly comparable because they may be calculated with diverse accounting conventions; however they give the reader an excellent approximation for analyzing the range of construction costs. These cost estimates are based on different foreign currencies with varying rates of inflation and fluctuating exchange rates. The International Union of Railways note that, historically, one HSR trainset costs between $32 and $40 million.

High-Speed Rail Project	Length (in miles)	Approximate construction Cost (per route mile)	Cost (in 2008 $)	Construction Completion Date
Europe		Dollars in millions		
Cordoba - Malaga (Spain)	96	$37	$3,558	December 2007
Madrid - Barcelona - Figueras (Spain)	468	$39	$18,223	February 2008
Paris - Strasbourg (France)	186	$42	$7,730	June 2007
Madrid - Valladolid (Spain)	111	$53	$5,894	December 2007
Japan		Dollars in millions		
Yatsushiro - Kagoshima	79	$82	$6,508	March 2004
Takasaki - Nagano	73	$143	$10,403	October 1997

Table 13. HSR Construction Costs Comparison(Source: [Y])

7.1.a Cost/Benefit Scenario

HSR has historically faced difficulty in generating adequate revenue to cover the capital investment and operating costs. Even in the strongest corridors, HSR will typically only be operationally profitable (revenues will cover Opex) but will not generate enough profit to cover the high construction costs (Copex). This funding gap is typically identified prior to open, yet, the corridor may still be developed as even with this deficit it may provide enough benefits to the public for the government to endorse the project and bridge the funding gap.

In a cost benefit analysis, the conventionally non-monetary effects associated with a project are quantified in a monetary amount. All of these benefits have an inherent public benefit that is not included in a standard economic analysis of a HSR line's feasibility. For example, the Texas Transportation Institute publishes a bi-annual report examining congestion levels in major cities as well as the cost of this congestion to the public. They reported that in 2007 the cost of congestion was approximately $87.2 billion for 439 urban areas, an average of $199 million in each area. Those numbers are even higher when focusing on larger markets, such as those that would be considered for HSR. In the nation's largest 14 urban areas, the average congestion cost per urban area was $3.55 billion. As congestion levels decrease so does gasoline consumption, pollution, foreign oil dependency, and time loss, translating into lower costs for many goods and services as well as higher productivity within the economy. A full detailed analysis of the cost and benefits to the public of HSR will be required to quantify the true cost/benefit impact to the public. This analysis will help determine if a particular HSR project serves a public purpose and is worth public funding. Additionally, this type of analysis can help the government rank potential projects and allocate funding accordingly **[37]**.

HSR projects also require a very long lead time. The lengthy development periods can increase the uncertainty over future costs and benefits and the front-loaded nature of the required spending can increase risk. The main challenge is securing the investment necessary to fund the substantial up-front capital costs, such as those incurred for planning and preliminary engineering, building the infrastructure, and acquiring train equipment. In addition, passenger fares are generally insufficient to finance the capital and operating costs of a HSR system, and the public "external" benefits cannot necessarily be captured in a revenue stream based on prices. Therefore, public subsidies are generally required, at least for the initial investment. In France, Japan and Spain, the central government paid the up-front construction costs of their country's HSR lines, and did so with no expectation that its investment would be recouped through passenger revenues.

7.2 Funding

Most of the actual proposed HSR projects indicate that they have or will need some federal or state funding to develop and construct their projects.

7.2.a Federal Funding

In the U.S., federal funding for rail in general, and HSR in particular, has largely been derived from general revenues, as opposed to trust funds or other dedicated federal funding sources that support other transportation modes. In addition, HSR projects must compete with other non-transportation demands on federal funds, such as national defense, education and health care, as opposed to only competing with other alternative transportation investments or policies in a corridor.

The other transportation modes are funded through federal programs – such as federal-aid highways, the FTA's New Starts Program, and the federal Airport Improvement Program which benefit from (1) dedicated funding sources based on receipts from user fees and taxes, (2) a format for allocating funds to states, and (3) in some cases, a structure for identifying projects to be funded. The following Figure 49 illustrates how state capital dollars can be leveraged by matching federal dollars for each mode of transportation.

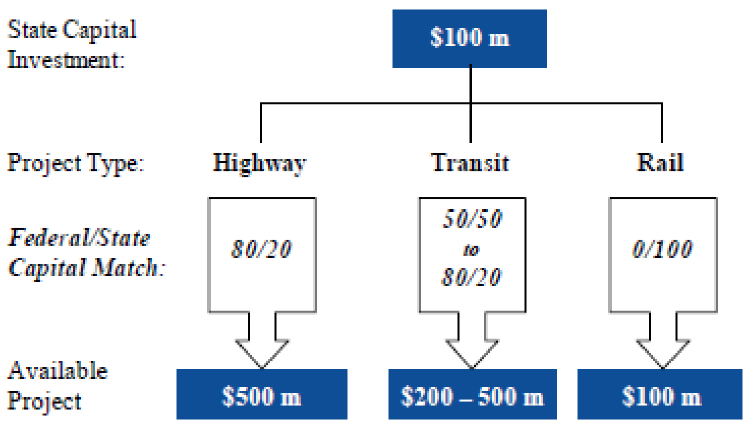

Figure 49. Example of Historical Federal Funding Leverage by Mode (Source:[9])

Given the lack of dedicated federal grant funding currently available for HSR projects, project sponsors are exploring other federal financing mechanisms for HSR projects, such as federal loan programs. Alternative federal funding sources, such as authorized under the Transportation Infrastructure Finance and Innovation Act of 1998 (TIFIA), are available, however, they may be limited in their ability to help fund the substantial cost of HSR projects or the number of projects competing for federal loans. The TIFIA program offers credit assistance to surface transportation projects and according to their documents, the $122 million authorized by Congress annually for the program provides over $2 billion in credit assistance. Sponsors of HSR projects could request that amount or more for one loan, thereby constraining TIFIA’s ability to fund other projects in the same year.

Other challenges may arise as well. For example, because TIFIA assistance cannot exceed 33% of a project’s construction costs, project sponsors must secure other sources of funding to construct a project, which can prove difficult. In addition, the availability of TIFIA funds, or other federal funding, may be questionable since the federal government faces significant future fiscal challenges. Lastly, the TIFIA program’s requirement that loans and loan guarantees be repaid may be another limitation on the program’s usefulness in funding HSR projects.

As mentioned before, in France, Japan and Spain, the central government generally funds the majority of up-front costs of their country’s respective HSR projects, and they do so without the expectation that their investment will be recouped through ticket revenues. The public sector’s ability to recover its financial investment has varied on the basis of how revenues have grown, but in Japan and Spain a public subsidy was generally necessary because ticket revenues were insufficient to fully recoup the initial investment. In Japan, while two early lines developed in the 1960s and 1970s may have fully repaid the initial investment and debt related to their construction, three of the HSR lines built since the 1987 privatization have been able to recover 10%, 52%, and 63% of their construction costs through ticket revenues. In Spain, the original high speed line between Madrid and Seville has been profitable on an operating cost basis but has not covered all of its costs, including the original construction costs. Also the government has told that future lines in this country might not cover even their operating costs.

7.2.b <u>State Funding</u>

Apart from federal funding, another important funding source is state funding. For HSR this can be limited by the lack of dedicated funding sources and restrictions on the use of gasoline tax revenues. Currently, none of the American project sponsors have obtained funding from a dedicated source of state funding for HSR; one project sponsor (i.e., the Virginia Department of Rail and Public Transportation), however, noted that it had a dedicated rail funding source available. Another report by the Brookings Institution, 30 states (including states where HSR projects are proposed, such as Minnesota, Nevada, and Pennsylvania) are restricted from spending revenues from excise taxes on gasoline, which typically is a state’s main source of transportation revenue **[38]**.

Instead of a dedicated source of state funding, some project sponsors have sought funding directly through appropriations of state revenue or bond measures, which compete with numerous other state budgetary needs. New York State DOT mentions that appropriations from general state revenue and bonding measures enable them to fund only incremental improvements along the New York, NY, to Albany, NY, corridor, and not to the major expansions that had been planned.

The choice of a financing mechanism can have serious implications for state and local governments, which will face broader fiscal challenges over the next 10 years, because of increasing gaps between receipts and expenditures. In November 2008, California voters passed a ballot initiative that would allow the state to issue $9.95 billion in bonds, $9.0 billion of which would go toward the construction of a statewide HSR system. According to information prepared by California, this bond issue, including principal and interest, could cost the state general fund about $19.4 billion over 30 years. Bonding mechanisms also may cost more than using appropriations of general revenues.

Another possibility is tax-exempt private activity bonds, which can be used to finance HSR facilities. These bonds are used for purposes such as transportation and water infrastructure, including HSR facilities. This means that the interest paid to bondholders is generally not included in the gross income of bondholders for federal income tax purposes. Private activity bonds allow tax-exempt debt to be used by private entities to help finance qualified facilities.

At first, such bonds were formerly restricted to high-speed intercity passenger rail facilities that operate at speeds in excess of 150 mph and proceeds could not be used for rolling stock (passenger rail vehicles). ARRA modified these restrictions to make eligible projects that are “capable of attaining” maximum speeds in excess of 150 mph, rather than operating at such speeds. This modification may increase the number of projects that can qualify to use tax-exempt private activity bonds for high-speed intercity passenger rail facilities.

7.2.c Attracting Private Capital

Given the significant financial risks HSR projects pose, it is difficult to obtain private financing. The Public Private Partnerships (PPP) can provide potential benefits, such as transferring some risk from the public to the private sector, and an increased potential for operational efficiencies. The level of private sector involvement anticipated by some American HSR projects is unprecedented, particularly given the limited private sector involvement with operating domestic HSR to date.

On the following pages, focus will be on the possible links between the public (federal government and states) and the private sector (companies). The addition of this connection to a proper business model can make the PPP, the perfect tool for HSR success in the U.S..

7.3 Public Private Partnerships

The major benefit of a Public Private Partnership is the fact that the goals of the private and public sectors are aligned. The success of a PPP is directly linked to the factors discussed below: the institutional and legal framework, the commercial, financial and environmental considerations, the stakeholder consultation, and the allocation of risk among the partners **[39]**.

7.3.a <u>Institutional and Legal Frameworks</u>

When engaging in a PPP, the roles and responsibilities of the public and private sector must be clearly defined. The private sector will expect that the appropriate legislative and institutional framework will be in place before engaging in the procurement. A public authority, with the legal capacity to engage in PPPs, will need to take responsibility for obtaining the required environmental clearance, approvals, facilitation of ROW acquisition and provide any necessary financial support for the project. This public entity will need to have support from the government including local, state, and federal level.

The public authority needs to manage the project from inception to completion. The designation of a lead authority for HSR is complex as many of the corridors identified in FRA EOI include connections to destinations across states and would require multiple agency participation and collaboration. Unless effectively addressed, this issue has the potential to create legal and institutional impediments that will delay the process.

Clarifying the role, form and responsibilities of the public and the private sector is a precondition to project development. Until then, development priority should be given to corridors situated in states with past experience or strong commitment to incorporate innovative financing and project delivery methods.

7.3.b <u>Commercial, Financial and Environmental considerations</u>

Rail PPPs are a developing concept and their application will require substantial legal, regulatory and institutional reforms to carry out the necessary contract procurement and administration. In particular, there will certainly be commercial, financial, and environmental considerations as will be discussed below.

Commercial considerations include:

- *Freedom to optimize route utilization:* HSR is most efficient when the stations are less dense and are spaced appropriately. The Operator will need the ability to designate stops along the line at optimal locations, which add sufficient demand to offset the time required to make the stop. Any excess political pressure to add stops to non-optimal locations will increase costs and reduce the overall efficiency of HSR. The Operator will also need the ability to set its own service frequency and the ability to run express trains or skip stations as it see fits to maximize the feasibility of the project.

- *Freedom to set fares:* Unlike traditional transport PPPs where toll rates are limited by the concession agreement, the Operator must have the ability to charge market fares for their service. Any attempt to limit the fare-setting ability will result in reduced operational viability, and possibly create the need for an operational subsidy. For instance, in Europe some low cost airlines have cut prices to compete with HSR. Without the ability to react to this type of action, the HSR will not generate optimal revenue.

Financial considerations include:

- *Funding subsidies:* Due to high construction cost, projects will require significant financial support for them to reach feasibility. The profitability of the line will determine if these subsidies extend beyond the construction period and into the operational period.
- *Government sponsored financing mechanisms:* The key government mechanisms are the TIFIA and the RRIF program. In order to reduce uncertainty regarding the RRIF program, it would be beneficial for funds to be appropriated prior to the beginning of a competitive procurement process. Additionally, other tax beneficial financing mechanisms could be implemented to improve the feasibility of the project.
- *Appropriate risk mitigation:* To obtain debt financing, the developer will need a level of certainty regarding the financial viability of their revenue source. If the government is paying for the availability payments, these payments must have a seniority level equal or higher than general obligations bonds issued by the same governmental authority. If the source of the availability payments is a newly formed multi-state authority, the payments will need to be backed by the various states or the federal government. Methods of backing could include direct guarantees or an initial capitalization of the newly formed entity.
- *Tax considerations:* The development of the project will need to be structured to reduce or eliminate certain tax obligations. Examples of this include, but are not limited to, property taxes on the land.

Environmental considerations include:

- *Environmental clearance:* The project will require that an Environmental Impact Assessment is conducted to assess the natural, social and economic benefits and impacts of the project. Generally, the private sector will only embark on a project if the environmental clearance process is substantially underway and the private sector will be hesitant to submit a bid until the process is complete. Full environmental clearance in a corridor will be required before reaching financial close.
- *Process acceleration:* As a measure to accelerate project development, the FRA should consider ways to make the environmental clearance process executed in a more timely and efficient manner.

7.3.c Risk Allocation

An effective risk allocation between the involved parties will result in costs savings over the lifecycle of a project. The risk must be allocated to the party that is best able to manage it at the lowest cost. Risk allocation generally comes with the precondition that when the public authority or grantor transfers risks to the private sector, the rights and authority to manage such risks are transferred with it (see Table 14). For facilities such as roads, bridges and tunnels, as well as other transportation facilities including ports, airports, and rail, the private sector typically manages the following risks included with the infrastructure: design, construction, financing, operations and maintenance.

ALLOCATION OF RISKS	RESPONSIBILITY		
	GRANTOR	PRIVATE DEVELOPER	OPERATOR
Environmental Clearance	●		
Archeological	●	●	
Geotechnical condition		●	
Hazardous materials	●		
ROW / Access to the land	●	●	
Engineering risk		●	●
Utility relocations		●	
Construction		●	
Community & Government relations	●	●	●
Warranties, hand-back procedures		●	●
Operations and Maintenance		●	●
On-going capital improvements			●
Rolling stock			●
Demand and Revenues	●	●	●
Tariff setting	●		
Financing	●	●	
Changes in law	●		
Force Majeure	●	●	●

Table 14. Risk Allocation and Responsabilities (Source: [34])

Regardless of the procurement and operation methods that are implemented, it should be clear that the transfer of demand and revenue risk to the developer is not considered practical or cost effective for the public authority. For example, there is little value in transferring demand risk if the project is unable to generate sufficient revenues to pay for the development phase.

Proper risk allocation must occur in the beginning of the process to prevent obstacles from developing in the final process stages. Improper risk allocation itself can create unforeseen risks such as increased costs in operations, construction, financing or inability in the final steps to reach financial close.

7.3.d Stakeholder Consultation and Political Support

There should be an early and constant dialogue between the government, various stakeholders and the private sector to define the objectives and contractual structure of a HSR PPP. The designated public authority will need to have the political will to lead and ensure a transparent process is conducted. An early dialogue with all stakeholders will allow the government to understand the stakeholders' expectations, identify political constraints, and identify potential project risks. If any significant issues arise, they should be resolved promptly, and certainly before competitive proposals are due.

In structuring the procurement process, private investors should be engaged to comment on the proposed project structure to ensure they include the following:

- sufficient opportunity for private sector innovation
- appropriate business model structure
- efficient risk allocation

This dialogue will ensure the project will provide benefits to both public and the private sector. Once the PPP moves to the implementation phase, public consultation will remain critical to raise public awareness and support for the project.

7.3.e Project Procurement

Project procurement involves a formal process of public notice and solicitation to bidders. The process generally includes the issuance of a Request for Proposals (RFP) instructing proposers of the rules and terms of the anticipated bid process, the evaluation criteria, and a draft form of the concession agreement. Often, this process is preceded by a preliminary stage seeking to gauge the interest of and prequalify potential bidders through the release of a Request for Expressions of Interests (RFEI) or a Request for Qualifications (RFQ). In the RFQ phase, the criterion is largely based on the financial and technical capabilities of the bidder, as well as the relevancy and extent of prior project experience of the companies involved. In the RFP phase, proposals are evaluated in terms of the technical and financial value they provide.

7.3.f Project Delivery

The involvement of the private sector in the delivery of transportation infrastructure can help improve the cost effectiveness and timelines of project delivery by combining design and construction phases under a single contract, as illustrated in the Figure 50.

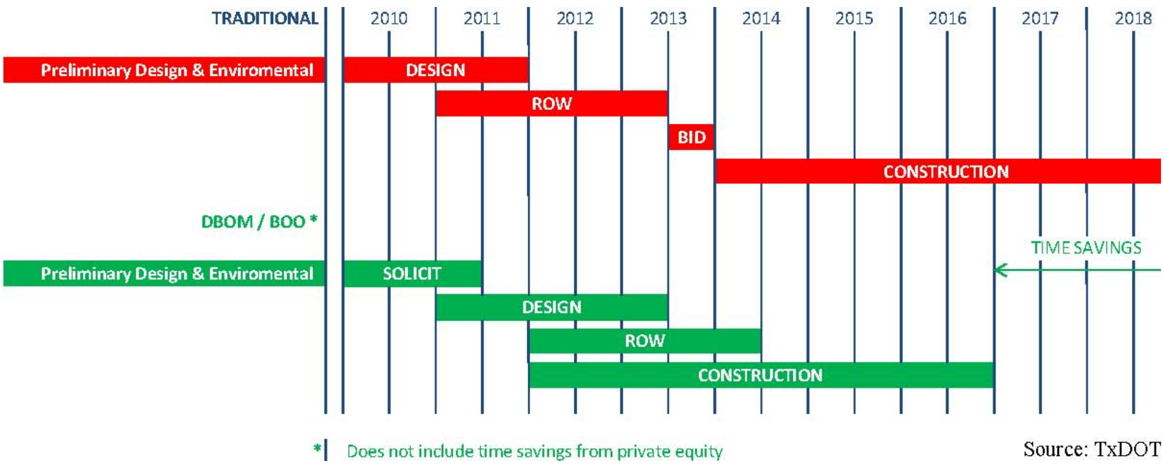

Figure 50. Construction Phases and Timelines of a Traditional HSR Project (Source: [AA])

All stakeholders are a component of the schedule and unless properly coordinated, the time savings provided by the private sector will erode and compromise the value of the project.

7.4 HSR Business Models

Since the first HSR line inaugurated in Japan 45 years ago, several business models have been utilized for the development of HSR lines. Recently, there has been a shift in the trend from a fully public sector model to a public and private sector partnership. This trend has allowed for the transference of the responsibilities of the different components of the system to the private sector – i.e. track development and maintenance, service operations or signaling.

There are different types of contracts that can be used for a HSR project. Each of them involves public and/or private entities for various stages of design, construction, and operation. Provided in this section is a description of these alternative business models with examples of countries that have developed HSR lines in the past decades.

7.4.a Design-Bid-Build (DBB, Traditional Model)

Traditionally, civil infrastructure projects in the U.S. have been delivered through the use of DBB contracts. Under these arrangements, a state usually contracts design and construction to separate private entities while retaining the finance, ownership, operation, and maintenance responsibility. This model was heavily used during the early development of HSR in Europe. Table 15 assigns responsibilities among the public and private sector.

			Design	Build	Finance	Operate	Maintain	Own
Design Bid Build	Responsibilities	Public			X	X	X	X
		Private	X*	X*				
** The public sector retains control over design and construction by contracting separately initial design and construction to the private sector . However, changes in design during construction may lead to costs overruns and construction delays.*								

Table 15. Design – Bid -Build (DBB, Traditional Model) Schematic (made based on Source: [40])

Two clear examples that have been following a DBB model are France and Spain.

France has historically been the European leader of HSR infrastructure. Formally, the finance was handled by the government through a number of lump-sum construction payments and operational subsidies, intended to assure the profitability of the operations. The design and construction used to be subcontracted to the private sector and initially the operation and maintenance was the responsibility of the fully public company SNCF. After the 1997's legislation reform, RFF has received financing through the collected infrastructure charges paid by rail operators such as SNCF. The charges consider the cost of infrastructure, the situation of the transport market and characteristics of transport supply and demand, the requirements for the optimal use of the rail network, and harmonization of intermodal competition.

Spain's rail network has historically been financed through the national government's funding contributions to the public railway company, RENFE. The company both operated trains and managed the railway infrastructure. Now, ADIF owns the Spanish high-speed system, the passenger and freight stations and the telecommunications network. ADIF is also is in charge of managing rail infrastructure (tracks, stations, freight terminals, etc) and rail traffic, allocating track usage rights to rail operators, and the collection of fees for infrastructure, station and freight terminal use. RENFE now is the public operator, similar to SNCF's new role in France. Government funding contributions in the Spanish DBB model come from a variety of sources: budgetary investments (through ADIF), subsidies and tax exemptions, and debt financing (financial institutions and European Investment Bank (EIB). European Union funding contributions also come from a variety of sources: The Cohesion Fund, European Regional Development Fund (ERDF) and TEN-T subsidies. The additional subsidies from the EU have allowed for implementation of superior infrastructures, advancement of technological innovation, and increased environmental sustainability.

7.4.b Design Build Finance Maintain (DBFM)

The DBFM model is the most appealing PPP structure for the public and private sectors as the division of responsibility balances the benefits and risks. In this model, the public retains ownership and is responsible for oversight of the project including ensuring that the private sector meets its contractual infrastructure maintenance obligations. The private sector is responsible for the design, construction, finance, and maintenance of the asset. The private sector is able to bring innovative solutions to the design and construction process, and most importantly is able to access new funding sources unavailable to the government. This allocation of responsibilities ensures that the asset is constructed and maintained at a high level of quality.

Within the DBFM model, the train operations are a separate concession(s) and are handled by a public operator, such as Amtrak, or a separate private operator (Operator). Rail projects are large scale and are composed of a variety of clearly defined components which makes them ideal for separate concessions. Rail projects can be divided into the track construction and maintenance (the developer or infrastructure/asset manager), the signaling and technology components (the systems supplier) and the train operations (the operator). This is further illustrated below on Table 16.

		Responsibility
DBFM Private Sector Partners	Developer*	Infrastructure[1]
	Systems Supplier*	Control Systems[2]
	Operator*	Operations[3]

[1] Tracks, power supply, and other civil works
[2] Signaling and communications systems
[3] Rolling stock ownership, maintenance and operations
** A private sector partner can assume responsibility for more than one component when efficient and effective*

Table 16. DBFM Partners & Responabilities (made based on Source: [40])

Depending on the specifics of the corridor, a private sector partner could assume more than one of the responsibilities identified in the table above. In addition, a public regulator may oversee traffic management, network integration and regulatory responsibilities. To the extent that regulatory principles are included within the contract (contractual obligations, service standards and network connectivity considerations), these responsibilities may be passed down to the concessionaire or the operator, as applicable. The below Table 17 clarifies these responsibilities among the public and the private developer.

			Design	Build	Finance	Operate	Maintain	Own
Design Build Finance Maintain	Responsibilities	Public			X*	X**		X
		Private (Developer)	X	X	X		X	

** If project is not financially self-sustaining, finance assistance will be required of the government.*
*** Operator could be a public entity or a separate concession with another private sector company.*

Table 17. DBFM Schematic (made based on Source: [40])

Portugal is an example of a DBFM model. The Portuguese HSR network is in its startup phase and is note worthy as Portugal has chosen to lean heavily on the private sector. The model proposed by Rede Ferroviaria de Alta Velocidade S.A. (RAVE), utilizes a DBFM structure. RAVE is the public entity that handles the development and coordination of HSR activities in Portugal.

Portugal has chosen to separate the procurement of the HSR lines into the Developer and the System Supplier. The procurement process for the line Operator has not yet been structured. The Developer will be awarded a concession for 40 years and will be responsible for design, construction, financing and maintenance of the infrastructure. The System Supplier will be awarded a concession for 20 years and will be responsible for the signaling and telecommunications systems. At this stage, the Portuguese State will be responsible for acquiring the rolling stock needed for the operation portion of the project and as mentioned the structure will be determined as the process evolves.

France first structured most HSR lines with the traditional DBB but looking to expand their HSR systems, they are exploring private sector participation, among other reasons, to attract additional financing, and to tap private sector management and technical expertise with a DBFM model. France is contemplating a public-private partnership contract scheme where risks associated with financing, designing, building, and maintaining a HSR line are allocated to the private sector (see Figure 51).

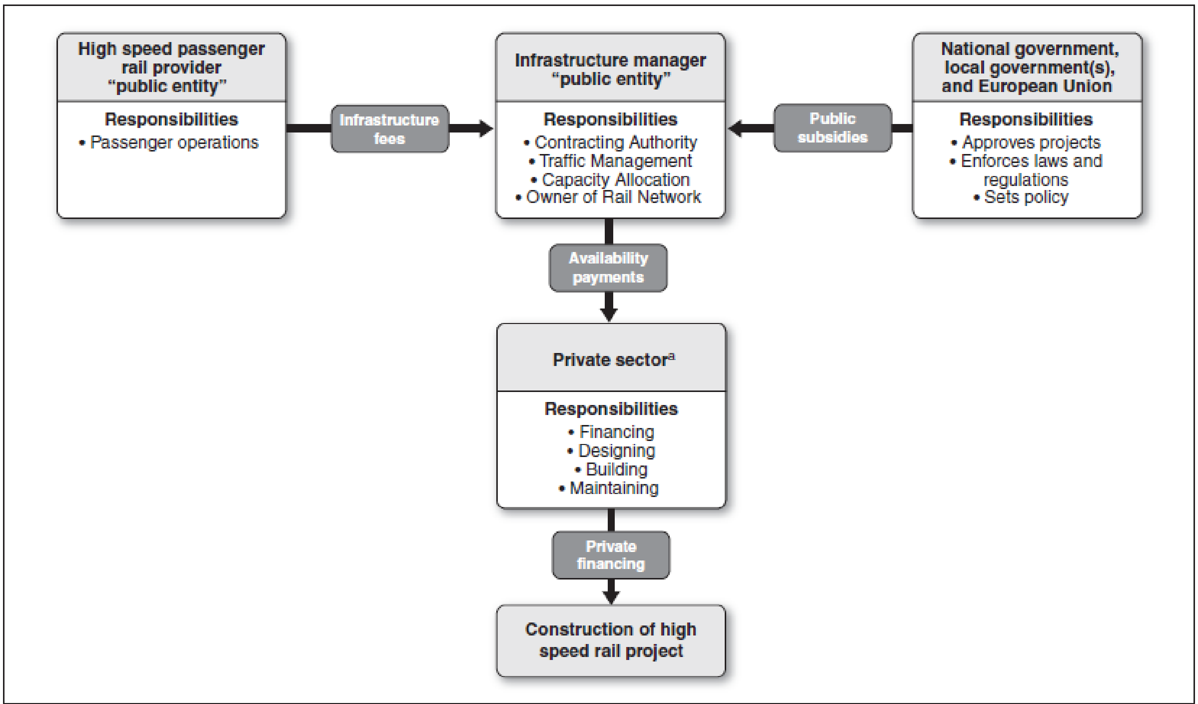

Figure 51. Proposed French and Spanish Public-Private Partnership Contract Model (Source: [Y])

7.4.c <u>Design Build Finance Maintain Operate (DBFMO)</u>

In the DBFMO model, the private sector is responsible for the design, construction, finance, and maintenance of the asset as well as the operation of the trains (see Table 18). The government still retains ownership and oversight capabilities. The limitation of this structure is that often the scope and risks associated with the project are too great for one consortium to manage.

		Responsibility
DBFOM Private Sector Partners	Developer	Infrastructure[1]
		Control Systems[2]
		Operations[3]

[1] Tracks, power supply, and other civil works
[2] Signaling and communications systems
[3] Rolling stock ownership, maintenance and operations

Table 18. DBFM Partners & Responabilities (made based on Source: [40])

The below table 19 clarifies these responsibilities among the public and the private developer.

			Design	Build	Finance	Operate	Maintain	Own
Design Build Finance Maintain Operate	Responsibilities	Public			X**			X
		Private	X*	X*	X	X	X	

** The public sector retains control over design and construction by contracting separately initial design and construction to the private sector.*
*** If project is not financially self-sustaining, finance assistance will be required of the government.*

Table 19. DBFMO Schematic (made based on Source: [40])

With a DBFMO, in Japan (where the rail system was privatized in 1987) the national and local governments still assume the financial risk of constructing a new HSR line, investing 2/3 and 1/3 of the construction costs, respectively (see Figure 52). With the government's financial commitment, the private railroad operating companies undertake the operational risk and rely on ticket revenues to cover operating and maintenance costs. The railroad operating companies business model, which includes various business ventures and non-rail revenue streams, also helps them assume this risk for rail lines with relatively low numbers of riders, since these additional revenues may be able to cover HSR operating losses, if they occur.

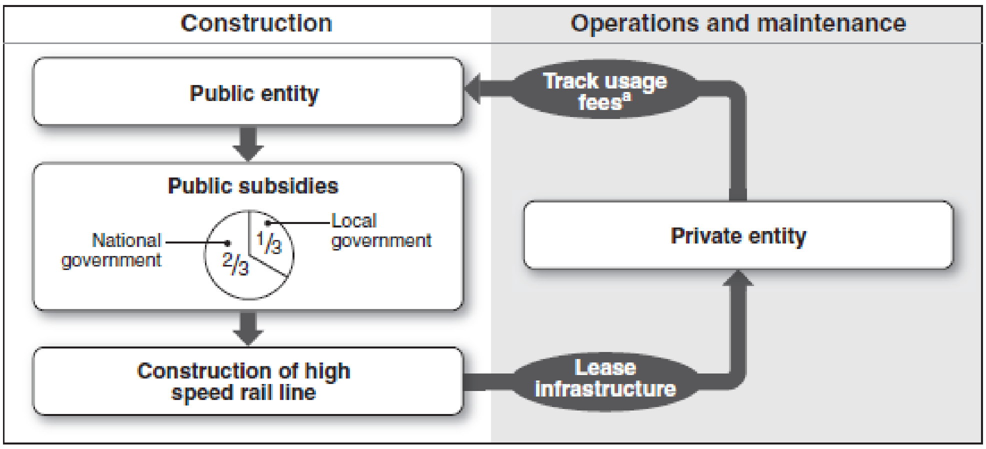

Figure 52. Public and Private Sector Roles in HSR Development and Operation in Japan (Source: [Y])

Florida attempted to enter into a DBFMO in 2002 for its Tampa to Orlando corridor. The Florida HSR Authority (FHSRA), which had the right to enter into agreements with private companies, issued an RFQ for a business model establishing that the concessionaire would provide all design and civil infrastructure, including the signaling, control systems, and rolling stock components, and have a 30 year operations and maintenance contract. The contract was structured such that the public sector was heavily protected from revenue risk and would retain ownership of the system and its components as well as the right to any excess operating revenues. The public sector would provide a yearly subsidy to the private concessionaire, a maximum of $75 million a year, to cover the infrastructure and operating costs. Though a private bidder was selected and complied with the Florida business model, the public sector, particularly the state government, was reluctant and withdrew their pre-committed financial commitments. With the loss of these funds and no way to guarantee the payment of the yearly availability payment to the concession company, the project became unfeasible. The process is currently being reexamined as a candidate for the ARRA funds.

The Texas TGV project also was a DBFMO business model allocating the responsibilities for the design, construction, finance, operation, and maintenance of a HSR facility to the private sector. The private sector was to bear all risks including the revenue risk. The public sector would have been involved only in a regulatory role and would have not provided any subsidies. At the end of the procurement process, a private sector company, which had initially submitted a compliant bid, was selected. Unfortunately, the private sector partner was unable to secure financing, and the concession process was canceled.

7.4.d **Build Own Operate (BOO)**

The BOO PPP structure is seldom used for transportation projects as typically the ownership remains with the public sector, and in the BOO the private sector takes on the ownership and all risks associated with the project. The below table 20 clarifies these responsibilities among the parties in the BOO structure.

			Design	Build	Finance	Operate	Maintain	Own
Build Own Operate	Responsibilities	Public						
		Private	X	X	X	X	X	X

Table 20. BOO Schematic (made based on Source: [40])

The BOO model has been less frequently applied for the development of transportation infrastructure as government entities are reluctant to part with their ownership and regulatory role in a project. Efforts to develop entirely privately financed HSR projects in the U.S. have proven unsuccessful to date. Currently, a private company, DesertXpress Enterprises, is investing a substantial amount of resources in developing a HSR line called the Desert Xpress project from Victorville, California, to Las

Vegas, Nevada. As of February 2009, the project had not secured private financing. This project has made progress on its planning and environmental review studies, but has not yet started ROW acquisition or construction. If this project is successful, it will represent the first BOO HSR line in the US.

All of these business models offer different advantages and disadvantages in their allocation of responsibilities, and a summary of the responsibilities of each model is provided below on Table 21.

	Design	**Build**	**Finance**	**Operate**	**Maintain**	**Own**
Design Bid Build	Private sector[1]	Private sector[1]	Public sector	Public sector	Public sector	Public Sector
Design Build Finance Maintain	Private sector	Private sector	Public/Private sector[2]	Public/Private sector[3]	Private Sector	Public Sector
Design Build Finance Maintain Operate	Private sector	Private sector	Public/Private sector[2]	Private sector	Private Sector	Public Sector
Build Own Operate	Private sector	Private sector	Private sector	Private sector	Private Sector	Private Sector

[1] *The public sector retains control over design and construction by contracting separately initial design and construction to the private sector . However, changes in design during construction may lead to costs overruns and construction delays.*
[2] *If project is not financially self-sustaining, finance assistance will be required of the government.*
[3] *Operator could be a public entity or a separate concession with another private sector company.*

Table 21. Summary of Allocation of Responsibilities for the different HSR Models (made based on Source: [40])

7.5 Public Sector Challenges

After analyzing the previous HSR business models and the public sector concerns, there is a need to address several challenges before to obtain economic viability on the designated HSR corridors in the U.S.. These public sector challenges can be described below.

7.5.a <u>Timelines</u>

HSR projects require long lead times. In France a HSR project takes approximately 14 to 16 years to complete. This time comprises when project planning begins to when the project opens for revenue service. A considerable amount of this time is for studies and analysis as well as public debate about the merits of a project. Sustaining public support over this length of time can be difficult and have significant impacts on a project. As the experience with the FOX project demonstrated, development of HSR projects can occur over multiple electoral cycles, which not only can change the course of project development but can also lead to project termination if public and political support is not sustained. For example, as explained in a previous chapter, the Florida DOT had planned to provide $70 million annually to help construct the FOX project. The project began under one gubernatorial administration that supported the project. The project was terminated under a different administration that did not support the project.

There is always a need for someone or some organization to champion a project over a long period of time. Historically it appears that it is easier to sustain public support for a HSR project once it has the commitment of the central government.

7.5.b Transparency and Confidence

There are also challenges associated with the ability to provide transparency and confidence in project cost estimates and rider forecasts. These estimates and forecasts can often be inaccurate, which may erode public support for HSR. During the FOX project, advocacy organizations and state transportation agencies questioned the reliability of project cost estimates and rider forecasts. The governor of Florida decided to cancel state funding for the project, in part due to the skepticism raised by these organizations. Cancellation of state funding led to termination of the project. More recently in California, a report by numerous advocacy organizations raised similar concerns about the rider forecasts and costs estimates for the statewide HSR project. Although the public approved a nearly $9.95 billion bond to support this project, over time public support could erode, along with public funding, if confidence in rider, revenue, and cost estimates is lost.

7.5.c Reaching Consensus

Reaching consensus on project decisions, such as a rail line’s actual route, involves difficult negotiations, which can cause substantial project delays and disagreements among stakeholders. Given that HSR projects can span hundreds of miles and occasionally cross multiple states, numerous stakeholders and jurisdictions are involved. Stakeholders typically include, among others, federal, state, and local governments; the private sector; and advocacy organizations. For example, the Southeast HSR Corridor (a project from Washington, D.C., to Charlotte, North Carolina) involves some 50 federal, state, and local government agencies as well as a 214 member advisory committee. Coordinating on project decisions with these stakeholders (each with their own priorities and views) can be difficult, particularly without an established institutional framework within which this can occur, as exists for other transportation modes. For example, in planning highway and transit projects, federal agencies, local transit agencies, metropolitan planning organizations, and state transportation departments benefit from established procedures for planning and public involvement.

Development of domestic HSR projects may typically be led by rail divisions within state DOTs or by HSR authorities and commissions. These organizations are often limited in terms of institutional and financial resources. In the case of the California HSR Authority, funding has fluctuated from a little over $1 million per year to reaching just beyond $14 million as a result of changes in its annual appropriation from the state legislature. The $3.9 million in state funding for fiscal year 2005-2006 was planned to support approximately four staff members in developing a $45 billion, 800-mile statewide HSR system **[Y]**. Rail divisions within state DOTs also face similar funding and manpower issues, since there is typically no dedicated state funding for rail service. In addition, rail has generally not been a primary focus of state transportation plans, which tend to be more focused on highway projects.

7.5.d Define the Role of the Authorities

The role of HSR authorities is many times unclear. Rail authorities can at times be conflicted between advocating for a HSR project and objectively determining whether a system is in the public convenience and necessity. In the case of incremental projects, stakeholder consensus among Amtrak, commuter railroads and private freight railroads can be difficult because each one has its own interests. Projects that cross state lines pose additional stakeholder challenges, particularly with respect to allocating benefits and cost among the states. To address multistate issues, some states have pursued interstate compacts and commissions as a means of formalized decision making. However, interstate compacts can be difficult to implement and involve work.

7.5.e Federal Leadership

Although the federal government in the U.S. has not historically exercised a strong leadership role in the development of HSR, the recently enacted PRIIA will likely increase the federal role. The PRIIA authorized annual funding (a total of $1.5 billion for fiscal years 2009 to 2013) for HSR corridor development across the entire U.S.. ARRA appropriated $8 billion for HSR and intercity passenger rail congestion and capital grants (the latter of which were authorized by the PRIIA). However, this funding will not likely be sufficient to fund large-scale projects. For example, project sponsors for the proposed HSR line between Los Angeles, California, and San Francisco, California, are anticipating $12 billion to $16 billion in federal funding alone yet, according to the California HSR Authority, total project costs are expected to exceed $40 billion if the entire system is constructed.

The national rail plan required by the PRIIA provides an opportunity to identify the vision and goals for U.S. HSR and how HSR might fit into the national transportation system already in place. Identifying the appropriate federal role in achieving the established goals will also be vital to success of HSR. Previously, there has been little effort to identify the role of HSR, and the national rail plan required by the PRIIA does not explicitly include HSR, although it must be consistent with state rail plans that are, among other things, to include a review of proposed HSR lines. In France, Japan and Spain, national rail plans have proven instrumental in guiding HSR development.

8. TECHNOLOGICAL DEVELOPMENT & SUSTAINABILITY OF THE FUTURE U.S. HSR CORRIDORS

HSR is used to improve the speed and efficiency of ground transportation by moving people and freight while benefiting the environment. HSR reduces oil consumption, CO_2, CO, Nox emissions and total organic gases. HSR also uses energy more efficiently in comparison to airline or automobile travel. At its core, HSR is a product of evolving innovation and technology. Much of the technology behind HSR is an improved application of existing technology.

Building a new rail infrastructure eliminates constrictions such as roadway at-grade crossings, frequent stops, a succession of curves and reverse curves, and no sharing of ROW with freight or slower passenger trains, therefore maintaining higher speeds. Thus it incorporates advanced modern technology while remaining compatible with existing rail networks.

The basic technology options for HSR service include combinations of equipment, track, and propulsion systems. All equipment and track options and several of the propulsion options are in use or under development outside the U.S.. This technology can be broken into two main models: HSR Technology (and subsequently, High-Speed Tilting Technology) and Magnetic Levitation Technology (Maglev). The HSR Technology can be classified in improved conventional equipment on upgraded existing track or state-of-the-art equipment, partly or totally new track **[41]**. A brief discussion of each of these technology options and propulsion systems is presented below.

8.1 HSR Technology

HSR Technology is based on existing passenger rail technologies that use fossil fuels or overhead electrification for propulsion as shown on Figure 53 to the right. It utilizes steel wheels on steel rail to run along tracks designed to accommodate higher speeds than conventional passenger rail. Both the train and the track infrastructure dictate maximum operating speeds on HSR systems, which range from 90 mph to 220 mph or higher. As the maximum operating speed increases, so does the need for sophisticated train, signaling, and infrastructure technology.

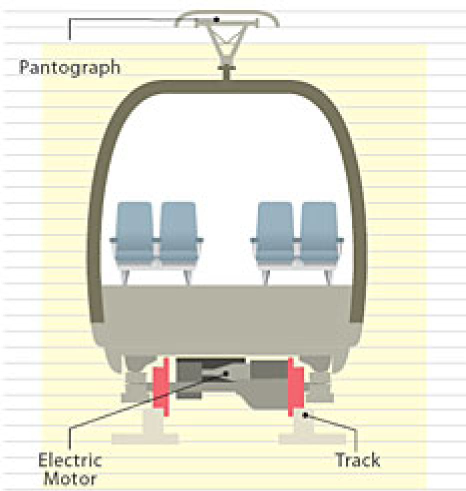

Figure 53. Example of train with overhead electrification for propulsion (Source:[BB])

8.1.a Improved Conventional Equipment on Upgraded Existing Track

HSR technology can be implemented on existing, dedicated track using very similar components as standard passenger rail. This least-cost option uses conventional equipment at a maximum speed of 125 mph on existing track shared with freight and/or commuter trains and foreign experience shows that such equipment can run comfortably and safely up to this speed.

Existing lines can slow HSR trains significantly due to the curvature of the track and when high-speed, freight, and traditional passenger rail share the same track, each one can operate at a different speed, which in turn affects the reliability of HSR on time performance. Frequencies of service are contingent on coordination with freight and commuter services and are adversely affected when the speeds of each service differ widely.

Grade crossings usually are eliminated on high-speed sections. Stringent safety precautions are required where freight shares the high-speed route with the passenger trains. New technology applied to vehicles and signal and control systems make faster trips possible on existing track. This existing track geometry together with bridges and tunnels, dictate the operating speed of HSR.

8.1.b State-of-the-Art Equipment, Partly or Totally New Track

Existing rail lines have established alignments and infrastructure that often are incompatible when speeds substantially above 125 mph are desired. In the U.S., the FRA has ruled that trains traveling faster than 125 mph must operate on tracks with no grade crossings (meaning no intersections with public roadways). Besides being essential to have a complete grade separation, the equipment must be designed to new and more stringent specifications to keep the ride quality and the forces exerted on the track within the proper limits. Lightweight materials, new and sophisticated signaling, and train control systems are desirable as are technologies that reduce weight and pressure on the track, and radii of curves must be increased. Where speeds are limited by curves, the use of tilting trains might improve trip times. For relatively small changes in elevation en route, heavier gradients can be used to reduce the need for expensive viaducts and cuts.

This option technically allows for design speeds up to 200 mph on new track between cities, though lower speeds typically are used in revenue service. Since its introduction in Japan in 1964, HSR technology has been continually improving. For example, while the initial Japanese Shinkansen (bullet train) Series 100 operated at 130 mph over 40 years ago, the new Series 500 and 700 Shinkansen trains currently operate with maximum speed of about 187 mph, but with greater efficiency, less noise, and more comfort than the Series 100, and have been tested at speeds of nearly 300 mph. East Japan Railways is testing prototype trains capable of in-service speeds of 224 mph.

The European experience has been similar. While the first French TGV trains operated at top speeds of about 168 mph, top speeds were raised to 187 mph with the introduction of next-generation TGV trains in 1989. Currently, TGV trains regularly operate with maximum speeds of 200 mph, but the TGV has been tested at nearly 360 mph. In February of 2008, Alstom (the maker of the French TGV) unveiled the prototype of the AGV (Automotrice Grande Vitesse) that was presented this October 2009, being its fourth-generation high-speed electric train. The AGV is designed to reach maximum commercial speeds of 224 mph, and Alstom already has its first customer: Italy's new railway operator, Nuovo Trasporto Viaggiatori, which has placed firm orders for 25 AGV trainsets and signed a maintenance contract with Alstom. Production of the first trains has begun, and they will start being delivered in 2010.

New steel-wheel-on-steel-rail high-speed train systems have begun operations at 187-217 mph in Spain, Korea, Taiwan, and China. European and Japanese networks are continuing to expand (for example Spain and Italy are investing about $30 billion each to expand their high-speed train and conventional rail networks, and the TGV network is being extended to the Netherlands). By 2020, most of Europe will be interconnected by a compatible, electrified, standard-gauge, steel-wheel-on-steel-rail high-speed train network.

8.1.c High-Speed Tilting train Technology

It is a well known fact that all vehicles, when travelling on a curved track, are naturally pushed to the outside of the curve, which makes the car bodies tilt in the same direction. In conventional trains, this effect is solved by reducing the speed on some curves. With a tilting technology system, this movement is reversed and the cars lean naturally "inwards" allowing higher speeds when negotiating curves while maintaining the same level of comfort for the passengers. The following figure represents how a passenger would feel a curve in a conventional train (on the right) or in a train using tilting technology (on the left).

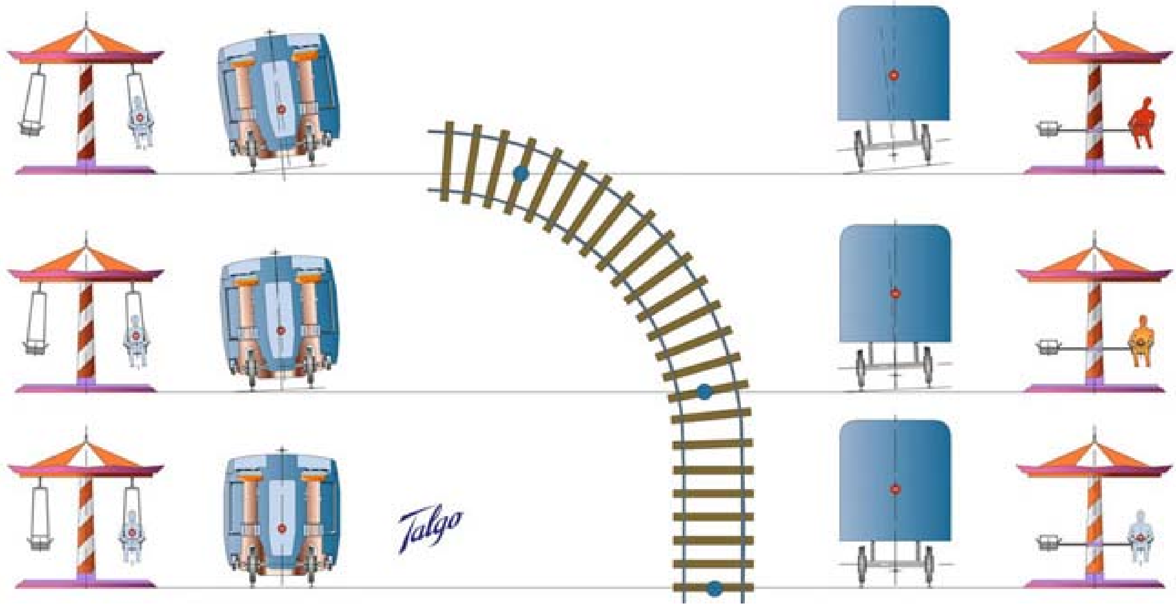

Figure 54. Curve feeling of a passenger in a conventional (left) or tilting (right) train (Source: [CC])

The high-speed tilting train technology is designed to provide comfort to the passengers when the train is traversing curves at speeds greater than that for which they are super elevated (banked). On tangent track and broad curves passenger comfort is assured by the pneumatic suspension that is an integral part of the tilting system. The natural tilting system makes use of the lateral centrifugal force, which naturally acts on the vehicles when they negotiate a curve to tilt the cars towards the inside of the curve, thus considerably reducing the centrifugal force experienced by the passengers (see Figure 55). An example of the use of this technology is the Amtrak Acela high-speed service on the NEC.

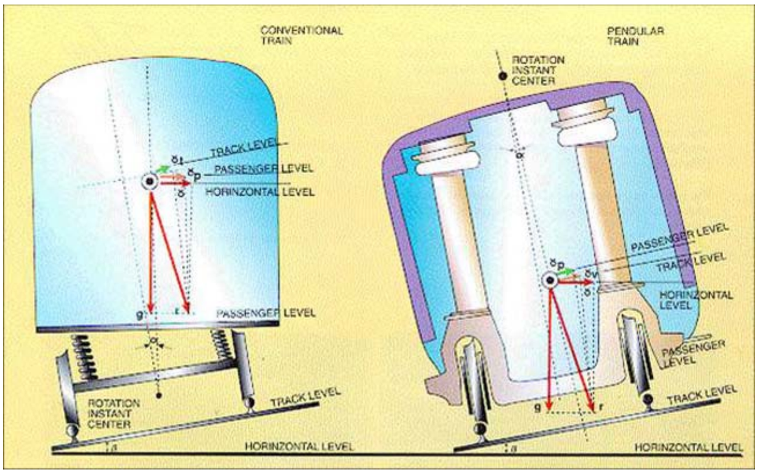

Figure 55. Forces configuration generated by a natural tilting system train (Source: [CC])

As the desired operating speed increases, advanced signaling systems and high-speed tilting train technology can maximize the benefit of existing rail infrastructure.

8.2 Magnetic Levitation Technology

An alternative technology to utilizing steel track HSR is Magnetic Levitation (Maglev) trains. These trains utilize an advanced technology that eliminates the need to use traditional steel wheels and other mechanical components. On the next page, Figure 56 shows a basic schematic comparison between the railroad and Maglev system.

The magnetic force is used to lift, propel, guide, and brake the train over a dedicated railway. Essentially, magnetic levitation is the use of magnetic fields, or magnetic forces, to levitate a metallic object. A Maglev train floats several millimeters above the guideway (track) and is powered by manipulating magnetic fields to produce sufficient force to lift and propel the train. This method of propulsion eliminates wheel/track friction, as is found with a traditional track. This method has the potential to be faster and smoother than wheeled mass transit systems, potentially reaching velocities comparable to turboprop and jet aircraft.

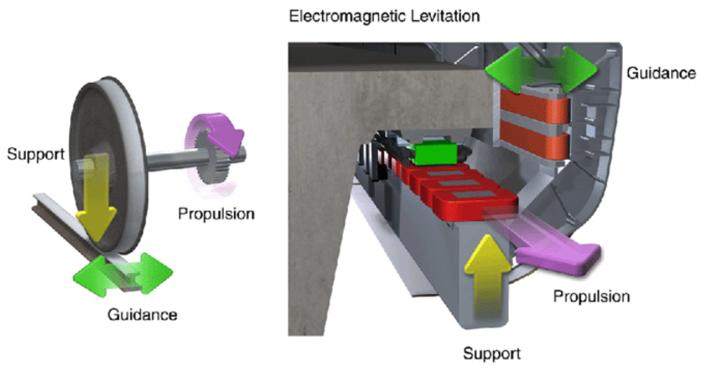

Figure 56. Comparison between railroad (left) & Maglev (right) rolling stocks (Source:[DD])

There are two main types of Maglev technology (Figure 57): electromagnetic suspension (EMS) and electrodynamic suspension (EDS). In EMS designs, the train chassis wraps around a guideway and, when current is applied to the rail, the train rises. With EDS technology, the train does most of the heavy lifting, as powerful magnets in the chassis generate an opposing force against conducting plates in a guideway. Each technology has its advantages and drawbacks: EMS trains can levitate at a standstill, but require a lot of sophisticated electronics to monitor and adjust the gap between train and track. EDS trains require less on-board intelligence but they need to build up speed on wheels before they can lift off the guideway.

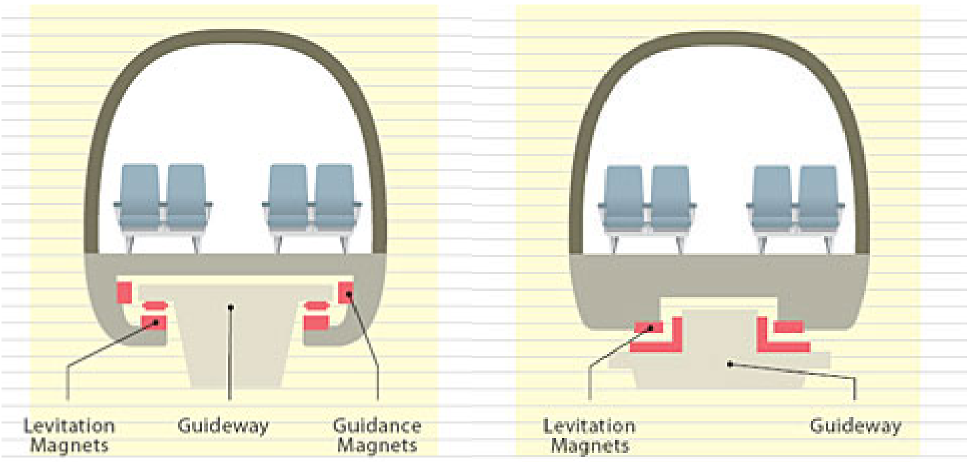

Figure 57. EMS Maglev (left) & EDS Maglev (right) systems (Source: [BB])

Maglev trains are capable of 300-plus-mph cruising speeds but a drawback to utilizing this system is that it does not benefit from an existing network of rail, and requires new grade separated guide ways.

The most well known implementation of high-speed Maglev technology currently operating commercially is the IOS (initial operating segment) demonstration line of the German-built Transrapid train in Shanghai, China that transports people 18.6 miles (30 km) to the airport in just 7 minutes 20 seconds, achieving a top speed of 268mph (431 km/h), averaging 160 mph (250 km/h).

To date, other Maglev test tracks exist in Germany, Japan, and the U.S.. Almost all of the Maglev projects in the U.S. are based on the more established EMS technology by Transrapid International, the German company behind the Shanghai and the planned Munich Maglev projects. EDS designs, on the other hand, are in the experimental stage. But the technology for both systems is still evolving.

Maglev proponents argue that it is easier to maintain (most designs do not include wheels, transmissions, brakes or axles, thus reducing the need for repairs). But Maglev's skeptics argue that lower maintenance costs are just speculation, since there aren't enough commercially operating tracks to know what real-world performance would be. Authority studies in China have shown that Maglev technology would have higher potential maximum speeds and could accelerate and decelerate more quickly, than steel-wheel-on-steel-rail technology but would require more energy to operate and be more expensive to build. The next Figure 58 shows a schematic view of the infrastructure used on each system.

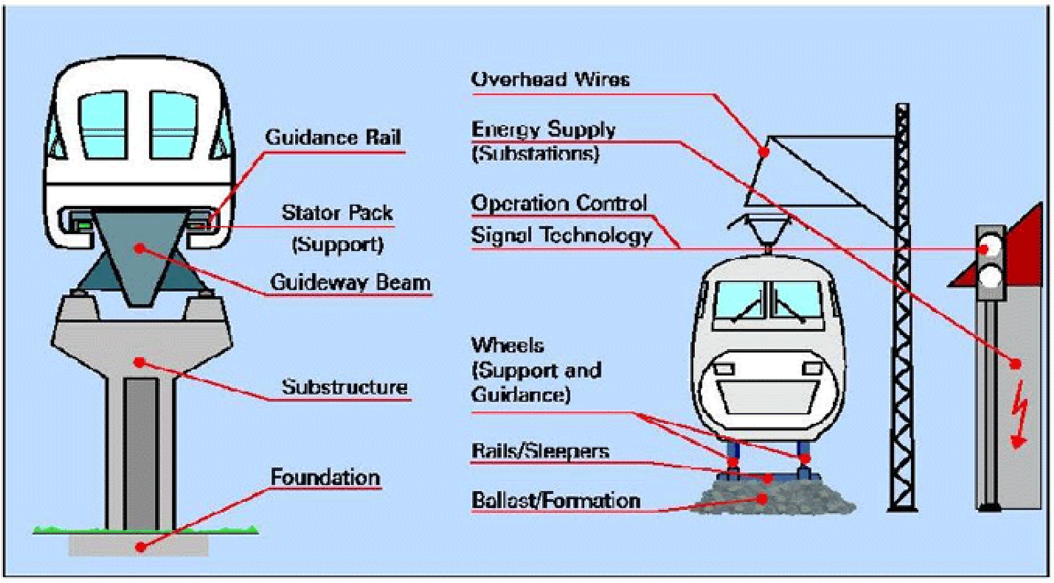

Figure 58. Comparison between Maglev & HSR infrastructures (Source:[DD])

8.3 Propulsion System

The propulsion system options include diesel power, electric power (including linear synchronous motors), and gas turbine power **[41]**. Gas turbine power has been virtually abandoned due to poor fuel efficiency. Linear synchronous motors are being developed for Maglev systems. Only electric and diesel power are suitable for state-of-the-art HSR systems. Diesel power is cheaper and more flexible than electric power for low-volume operations; however, electric power can provide improved acceleration, higher speeds, and better braking. It is less expensive than diesel for high density operations, and in the long term maybe preferred over dependence on liquid fuel.

8.3.a **Diesel Power**

The diesel power unit carries its own primary power supply (the diesel engine) with fuel for 1,000 miles or more. It uses an onboard generator to provide electric power to motors that drive the axles of the power car and to provide heating, cooling, ventilation, and lighting. Although limited in size and weight, the diesel-powered train is very flexible and can be moved around the system as traffic needs dictate. Nevertheless, a design speed much higher than 125 mph is regarded as impractical by engineers because of power constraints inherent in diesel traction.

8.3.b **Electric Power**

Electric locomotives basically are simpler, lighter in weight per horsepower, and cheaper to maintain than diesel locomotives. They make it possible to use at least twice as much power continuously as a diesel locomotive, with a significantly higher short-term power output and acceleration rate, as well as improved braking. However, the necessary overhead power supply installations and substations are very expensive, and existing signaling systems usually require renewal to prevent magnetic interference from the traction system. Replacement of signaling systems also is required to accommodate safe train spacing at higher speeds. To transfer the amount of power needed, high voltage systems are a necessity, usually by means of an overhead power supply. Whatever traction is used, as speed increases, unsprung axle load must be kept to lower values to avoid too great an impact on the track and vehicle. Unsprung axle load can be reduced by suspending heavy electric motors on the truck above the primary springs or on the vehicle body itself with flexible drive. Total weight on each axle also is important and must be reduced as speed increases to ensure good ride quality.

8.3.c **Gas Turbine Power**

While gas turbine power units offer the advantages of rapid power buildup and are very lightweight, the escalating fuel costs in the 1970’s and the engine’s lower efficiency except at full power led to the virtual abandonment of this technology.

8.3.d **Linear Motors**

To date, electric propulsion has used rotary motors carried on the train. With linear motors, the magnetic parts of the conventional rotating motor are replaced by a passive element on the vehicle and an active element in the track that interact to accelerate, maintain speed, or decelerate the train. Problems of power transmission and wheel to rail adhesion may be reduced by linear induction motors (LIMs).

Maglev vehicles use linear motors for noncontacting propulsion. A variety of such motor types have been developed and tested with Maglev vehicles; however, only the linear synchronous motor (LSM) currently is being developed for high-speed applications. While the principle of linear motors is simple, Maglev requires a sophisticated power conditioning and distribution system to control the proper amount and frequency of electrical power for propulsion.

Comparison of various propulsion system options indicates that diesel power is flexible and does not require a large capital expenditure for fixed installations for power supply. However, it limits train size and speed. Electric propulsion depends on expensive fixed installations but offers much higher power to weight ratio and thus larger and faster trains. For frequent service, it is simpler and cheaper to operate than the diesel and does not necessarily depend directly on oil as fuel. Gas turbine power has been discarded because of high fuel consumption and maintenance cost. LSMs for Maglev systems theoretically offer very-high-speed at reduced costs but require new guideway construction, and sophisticated power conditioning systems.

8.4 Future Technology & Rolling Stock in HSR Corridors in the U.S.

As discussed in several previous chapters, each HSR corridor in the U.S. is planning to use a different type of HSR infrastructure depending on its own interests. Some important factors such as cost, capacity, reliability, compatibility with old rail network or speed, are important when a country or state decides to invest in rail technologies. The next Table 22 summarizes these important factors depending on the three different types of technologies that America is planning to use.

	Incremental HSR	New HSR	Maglev
Price, Cost	Cheap	Expensive	More Expensive
Seating Capacity	50-60 per coach	60-80 per coach	Limited seating capacity per trainset
Reliability	High	Very high	Unknown
Compatibility with old rail network	Very high	High	No
Speed	90 - 155 mph	155 - 220 mph	> 250 mph

Table 22. Summary of Allocation of Responsibilities for the different HSR Models (made based on Source: [42])

Each HSR corridor in the U.S. is planning to start using one of these types of technology in its first steps of implementation of the HSR. Chapter 5 describes all the different corridors that are authorized for designation by the FRA in the U.S.. The following Table 23 summarizes all the corridors with the different types of technology that they are planning to use. It seems that almost all the HSR corridors in America are planning to start this venture improving the infrastructure on the existing rail network, investing and adding new add-ons. At this moment, California is the only State planning to build a new HSR network and is the one who has the most advanced plan.

Name of Corridor	Type of proposed Technology
Chicago Hub	Incremental HSR
Northern New England	Incremental HSR
Empire	Incremental HSR
keystone	Incremental HSR
Southeast	Incremental HSR
Florida	Incremental HSR
Gulf Coast	Incremental HSR
South Central	Incremental HSR
California	New HSR
Pacific Northwest	Incremental HSR

Table 23. Type of proposed Technologies in each designated corridor (Results from Chapter 5)

Last December 2008, the Secretary of Transportation announced that the FRA would begin accepting Expressions of Interest for the development of high-speed lines in the U.S.. By February 2009, more than 80 groups, including a number of states, train operators, and train constructors, had sent letters describing their interest in being part of the development of American fast train travel. Final responses were due on September 14th of this year. Appendix 4 **[EE]** refers the groups that submitted the basic information excepting the governmental agencies and other Corporations or Individuals, including small Engineering groups and Architects.

Recent news **[FF]** tell that SNCF, the French national railroad operator made famous by its development of the TGV system, has responded with detailed descriptions of potential operations in four U.S. corridors (California, Chicago Hub, Florida and Texas), all to benefit from train service at speeds of up to 220 mph. The organization refers to this service as HST 220 (220 mph HSR). With the exception of a description of plans by the California HSR Authority, SNCF appears to be the only group that submitted a serious, corridor-based response to FRA's demand, though infrastructure companies Vinci, Spineq, Cintra, Global Via, and Bouygues all sent in letters promoting rather vague interest in involvement. There is no funding associated with this call for expressions of interest; it is unrelated to the stimulus. Nonetheless, SNCF's large response exemplifies the degree to which it sees American corridors as a good investment and suggests that the French company is planning an all-out assault on future U.S. rail operations.

Important train manufacturers like Siemens, Alstom, Bombardier, Talgo or Hitachi have shown important interest in implementing their technologies on the new HSR corridors. Bombardier, Alstom and Siemens together, have over 55% of the shares of the global rail market. Bombardier is the leader at upwards of 20% followed by Alstom at a little under 20%. The other 45% plus of the market is made up mostly of small regional players with small market shares.

Appendix 5 **[GG]** includes a summary of some of the most popular trains built by these companies over the last decade and trains like these could be implemented in the U.S.

8.5 U.S. Passenger Rail Manufacturing Industry

There is currently no U.S.-owned passenger railcar manufacturer. U.S. manufacturers are not likely to decide to reenter the market and manufacture railcars unless the U.S. government (like other major Western countries and Japan) assures a stable, predictable, and planned rail equipment market that spreads orders out more or less evenly and in manageable sizes. Other factors likely to influence U.S. industry reentry into the railcar market are continued standardization of railcar requirements for the various passenger rail systems in this country, and continued improvements in some local procurement requirements.

It is unlikely that a U.S. manufacturer will decide to manufacture railcars, or be able to compete against foreign manufacturers, unless the U.S., like other industrialized countries with rail systems and rail manufacturing industries, has a stable, predictable, and planned rail equipment market, one in which orders are spread out in time and in manageable sizes **[HH]**. Suggestions about the reasons for the decline and demise of the U.S. passenger railcar manufacturing industry are described below:

- The steep drop over the past 50 years in the size of the U.S. intercity passenger railcar market, and in passenger rail's share of the growing travel market, as passengers increasingly chose other modes, particularly air and auto.
- The continuing erratic nature of U.S. urban rail transit orders, exacerbated by the sudden infusion, and later subsidence, of federal funds for mass transit between the late 1960's and the present.
- The entrance in the late 1960's and early 1970's of new U.S. aerospace manufacturers drawn in by the dramatic increase in Federal funds, the prospect of a growing mass transit market and by Federal encouragement. This market turned out to be too small to support all the suppliers;
- The lack of standardized equipment among various transit agencies plus the diverse special features required by them.

In practice the market for passenger railcars in the other nations with extensive nationalized systems is closed to outside manufacturers. The European and Japanese railway equipment construction industries historically focused nearly all their efforts on meeting domestic needs. The national railways, with the approval of the various governments, normally expect to buy equipment from suppliers within the home country, and only buy abroad when the home industry cannot supply what is needed. The manufacturers in those countries are assured of a stable, predictable market that is effectively closed to outsiders. Manufacturers abroad typically also have a close and continuing relationship with the railways, jointly conducting research and development with them and developing the basic designs. The national railway systems, which the foreign manufacturing industries support, are subsidized in accordance with explicit and consistent national policies that regard passenger rail service as a vital part of the national transportation system. In these countries, the passenger rail service and the rail equipment manufacturing industry function not as separate industries, but rather as two closely related and mutually supporting elements of what is, essentially, a single national passenger rail enterprise.

Based on examination of U.S. conditions and foreign markets, reemergence of a U.S. passenger railcar manufacturing industry is not likely to occur unless there is an assured and predictable market. Continued improvements in standardization of U.S. railcars, and continued improvements in procurement procedures also have been suggested as important factors in creating a climate favorable for manufacturer reentry into the U.S. market. However, the first requirement is by far the most critical. Without such a market, which all foreign railcar manufacturers have, no potential American manufacturer is likely to regard making railcars as a profitable line of endeavor.

8.6 Passenger Safety and Comfort

If HSR or Maglev will be introduced in the U.S., certain existing regulations regarding passenger safety and comfort would need review, and certification of new technologies would be necessary. The following is a brief discussion of the regulatory questions which would need to be addressed.

8.6.a Speed Limits

Currently the only HSR trains in the U.S. operate on sections of the NEC. Elsewhere, speed limits are generally 79 mph; speeds of 90 mph are permitted on small sections of track, and New York State now has trains operating at 110 mph on portions of its rail network. On many lines, lower speeds often are in effect because of track conditions or traffic mix. Limitations on speed usually are set for safety reasons. Restrictions on speed of passenger trains through curves are also based on passenger comfort, although the trains themselves could negotiate the curves safely at higher speeds. Speed limitations that would affect implementation of HSR cover such items as track conditions, signaling requirements, and maximum speed through curves.

Track Conditions: FRA track safety standards specify that the maximum allowable operating speed for passenger trains is 110 mph on Class 6 track, and lower speed must be observed on track of lower categories. France's TGV has a technical design speed approaching 200 mph and Japan can operate its equipment at 160 mph. In any case, the U.S. signaling requirements change according to the maximum speeds permitted.

Signaling Requirements: Signaling systems must assure the safety of HSR trains operation and the interoperability of these trains. FRA's existing signaling requirements limit train speed to 79 mph unless signals are displayed in the engineman's cab or intermittent inductive train stop equipment is in use. Some experts believe that above 125 mph, fully automatic train control should be part of the signaling system. Fully automatic control causes problems where high-speed passenger, commuter, and freight trains of widely different braking characteristics use the same tracks. In France, SNCF have increased the train speed for a given signal spacing by using more sophisticated braking systems, which can reduce the distance required to stop the train.

Maximum Speed through Curves: Speed limits through curves depend on the radius of curvature and the superelevation of the outer rail. When a train negotiates a curve, centrifugal force causes more of the total weight to be transferred onto the outer rail, and passengers are pulled toward the side of the seat nearer the outside of the curve. Thus, speed through curves is determined by the need to avoid or mitigate the following:

- Outward weight shifts that could cause the vehicles overturn;
- Overload on the outer rail so that it is displaced, and the train derails; discomfort to the passengers from excessive centrifugal forces; and
- Maintenance costs caused by these forces on the rail.

The lateral component of centrifugal force can be reduced by banking the track (superelevation). Very high superelevation (as on auto racetracks) would permit much higher speeds for passenger trains. However, if the track is also used for heavy, slow-moving freight trains, the weight of the train on the inner rail would be excessive and rapid wear and damage would result. Thus, superelevation in the U.S. is limited by Federal regulation to 6 inches.

8.6.b Safety and Strength Requirements of Passenger Equipment

Concerned about the possibility of collisions among dissimilar types of equipment, U.S. practice is to prescribe vehicle strengths for passenger equipment that are higher than those in Europe. As a result, U.S. passenger railcars are far heavier. Power requirements to move these heavier vehicles are correspondingly greater as is wearing on the track. European rail practice suggests that the U.S. specifications used for railcar equipment strength may, in fact, be counterproductive in a collision. However, such practices as well as energy savings from lighter weight equipment might well be investigated for possible adoption in the U.S.. Questions of shared versus dedicated ROW no doubt would be raised in the context of this issue assuming that heavier freight equipment would be operated on the same line with the new, lighter weight designs in passenger equipment.

8.6.c Safety Issues at the Highway/Rail Interface (Grade Crossings)

For safety reasons, any proposed high-speed system should avoid crossing highways at grade level. Grade crossing fatalities, though declining, represent the highest fatality category for rail in the U.S.. New York State has some non-grade separated rail crossings with special sensors for warning automobile traffic of approaching trains. Location of the grade crossing and type of equipment may dictate optimum grade crossing systems for HSR. Rail grade crossings may represent a significant public concern in any implementation plan for a high-speed system, according to State transportation officials.

8.6.d Safety Certification of HSR Technology for Operational Use

For the most part, HSR technology consists of tried and tested “off-the-shelf” technology. Two exceptions, which require separate consideration, are tilting equipment and Maglev. As discussed previously, the tilting train technology is intended to enable trains to travel faster through curves without sacrificing passenger comfort. Maglev for high-speed operation is so new that it has yet to be proved to be an operational largescale people mover for revenue service. Developers and prospective buyers are beginning to raise questions about which U.S. Government institutions should certify the systems and when they should be certified.

8.7 Environment and Sustainability

If there can be global consensus on the most pressing issue facing humanity today, sustainability would lead the field. Sustainability has received attention at all levels of human activity, both global and local, production and consumption. The most basic and salient argument for HSR in the U.S. is the pressing global environmental crisis and the role the U.S. plays in it. The scientific community overwhelmingly believes that anthropogenic fossil-fuel combustion is accelerating global warming. Meanwhile, the documented loss of biodiversity and ecosystem vitality is reaching epic proportions, and the concerns about the effects of pollution on human health persist. The U.S. contributes to environmental problems in a proportion that far exceeds its share of the world’s population, and transportation is a major component of this. The U.S. transportation sector finds itself locked into a heavily fossil-fuel dependent infrastructure.

A HSR system would thus, with respect to the problems of climate change and pollution, have dual direct and indirect impacts. It would directly diminish these forms of pollution by shifting travel away from fossil fuel intensive driving and flying. Indirectly, it would mitigate urban congestion by removing through traffic from the roadways decreasing pollution from urban commuters and freight shippers. The contribution of HSR to sustainability goes beyond its role in a more ecologically sustainable transportation system within the U.S. to its role in keeping the U.S. economy strong and its impacts on global development.

HSR is often cited as a solution to many transportation problems: It can reduce congestion on roads and at airports, is cost effective and convenient, improves mobility and has environmental benefits. The following Figure 59 shows a comparison of the energy efficiency in the different modes of transportation and how the HSR is the most efficient transport.

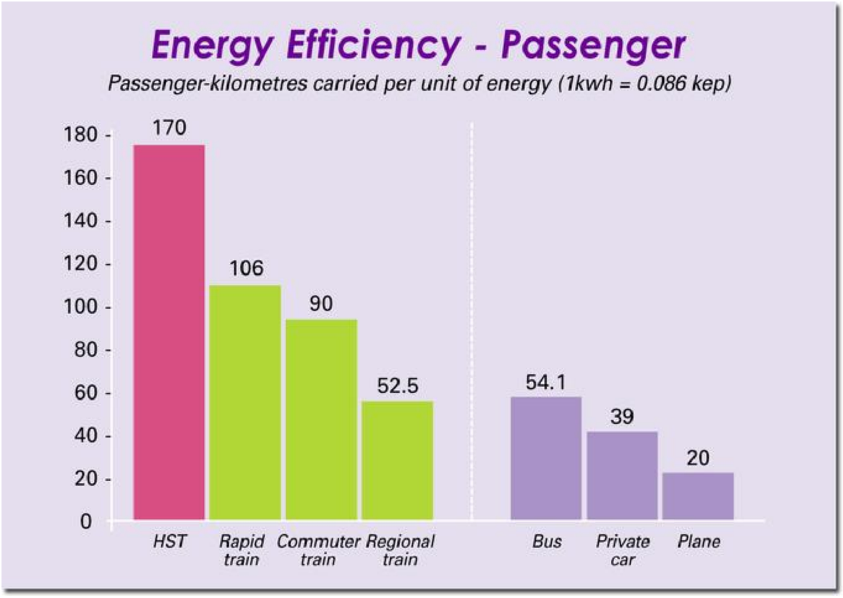

Figure 59. Energy Efficiency per Passenger for each mode of transportation (Source: [II])

While greenhouse gas (GHG) emissions are likely to be reduced as travelers switch to HSR from other modes of travel, little modeling has been done to estimate this potential impact in the U.S. In 2006, the Center for Clean Air Policy (CCAP) estimated on a corridor-by-corridor basis the annual GHG benefits of HSR systems in the U.S. using current plans for HSR development in the federally designated HSR corridors. To estimate HSR's net emissions impact, they calculated the carbon dioxide (CO_2) emissions saved from passengers switching to HSR from other modes (air, conventional rail, automobile and bus) and subtracted the estimated emissions generated by HSR.

The results showed that passengers would take 112 million trips on HSR in the U.S. in 2025, traveling more than 25 billion passenger miles. This would result in 29 million fewer automobile trips and nearly 500,000 fewer flights. They calculated total emissions savings of 6 billion pounds of CO_2 per year (2.7 $MMTCO_2$) if all the 10 HSR designated corridors would be built as planned.

As represented in the next page on Figure 60, the total emissions savings vary greatly by corridor, however, as do the source of those savings. In some regions, such as the Midwest, the impact on air travel is likely to be modest. In California, on the other hand, 19 million passengers are projected to switch from air. It is worth further study to see if such high levels of mode shifting are likely. In some respects, the California system, as it is currently planned, represents what will be the second generation of HSR in many of the other corridors. While areas like the Pacific Northwest may increase ridership sooner with an incremental approach to HSR that uses existing rail routes, the success of a new HSR system like California's could prove the value of faster trains with higher upfront capital costs.

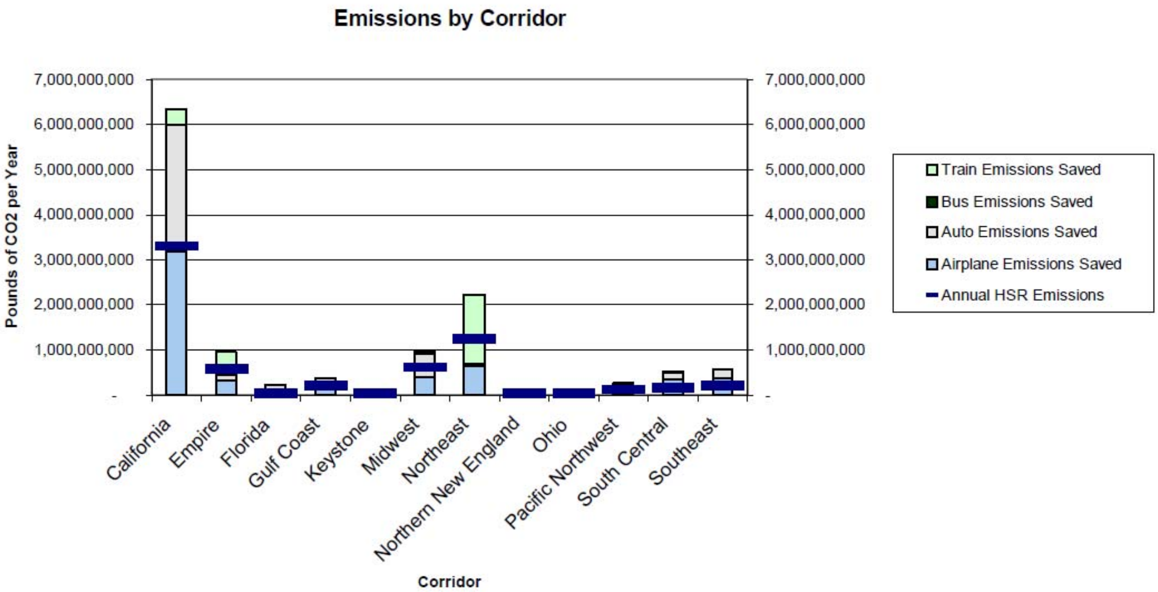

Figure 60. Emissions by Corridor and by mode of transportation (Source: [33])

Trains are the most sustainable & green form of transportation. Electric HSR is the most energy efficient of all trains compared with diesel powered and Maglev. The next Figure 61 shows the emission per train and emissions per passenger mile for several train technologies around the world. The Shinkansen 700, the ICE and the TGV Atlantique are electric HSR trains running in Japan and central Europe. The Danish IC-3 is a diesel powered train that has lower emissions per train, in part because of its slower speed (99 mph top speed) compared to other HSR technologies. Its low number of seats per train (152 maximum, 138 on the route used for these calculations), however, raises its emissions per passenger mile. The Maglev technology is the less energy efficient in pounds of CO_2 per passenger mile but at the same time is the fastest ground transportation technology.

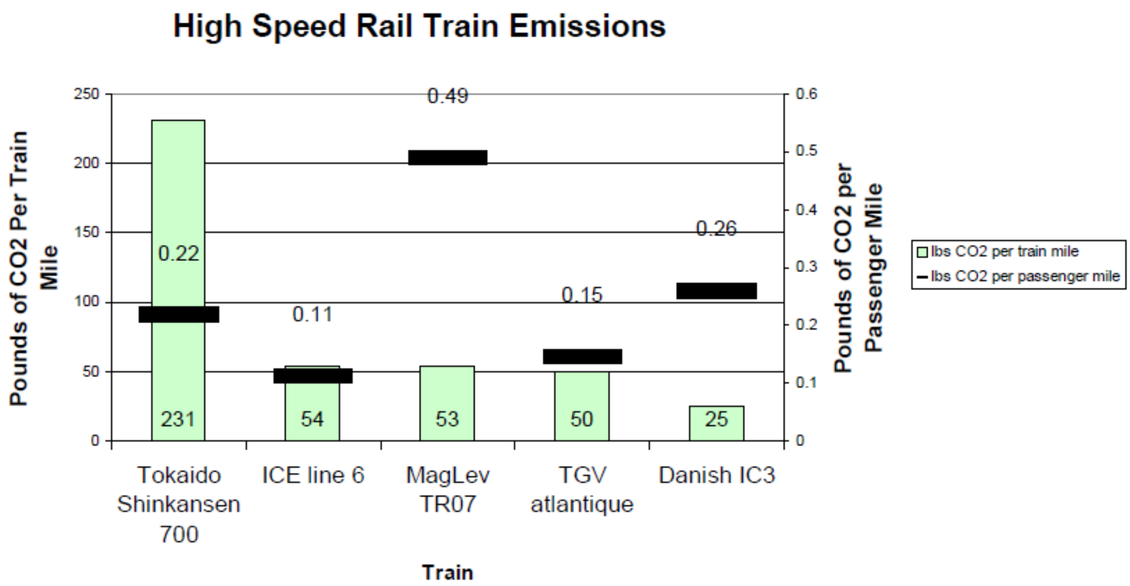

Figure 61. Examples of HSR Trains Emissions(Source: [33])

Apart from the energy efficiency of the different HSR technologies, there are other environmental concerns when deciding which one is going to be the best choice of HSR technology for each corridor in the U.S.. These other environmental concerns can be classified as the land use, the noise, the vibration or the visual pollution.

Land Use: While it is possible (by substantially limiting freight travel), to mix freight with passenger trains, HSR is often likely to involve separate dedicated tracks, if not dedicated ROW. Freight traffic aside, HSR could be instituted on existing U.S. ROW, although most corridors would require modification including upgrading of track, elimination of existing curves, and signaling improvements. Reaction of public and private groups to proposals to do so will depend on the impacts, benefits, and costs of the changes that have to be made. Land-use issues would be subject to negotiation. Proposals calling for the construction of entirely new ROW, or for any transportation alternative, will require public agreement on land-use questions. The degree to which local governments, institutions, environmentalists, individuals, or other citizen groups will support the implementation of HSR probably will be influenced by projections of demand for the service, by the amount of urban land and areas of natural beauty through which the line must travel, and by the perceived need to reduce congestion elsewhere. These basic concerns will not differ among most transportation alternatives studied.

The French avoided high capital costs and environmental opposition in building the TGV by using the existing line into and out of Paris. The population density of Western Europe indicates that the problems of building a new rail line between Paris - Lyon were made much easier by the relatively low density of population between the cities. Elsewhere in Europe, choosing an acceptable alignment would be exceedingly difficult if not impossible. In the U.S., the NEC and portions of Los Angeles are as densely populated as much of England, Ohio and Florida are more similar to France (but without any cities on the Paris scale of population) and Nevada has a far lower population density than anywhere in Europe.

In sum, assembly of urban land parcels in a line sufficiently straight to permit genuine HSR service is a legally complicated and costly undertaking. The irony of the land-use issue is that HSR promises to be most successful in corridors where there are many people to ride it, yet these very same densities make the establishment of new HSR lines exceedingly difficult and costly.

***Noise, Vibration, and Visual Barriers*: ** Japan’s bullet train, in operation nearly 20 years, initially produced severe noise and vibration due to the materials used in track construction. These problems have been mitigated for the most part by cushioning tracks on viaducts and erecting sound proof barriers along the ROW. The extent to which such problems exist and the measures necessary to satisfy residents of large urban areas through which the train would go probably depend on the type of HSR system in question and the measures taken to overcome any problems. The noise generated by various rail systems tends to differ slightly due to the way it is measured. Any train traveling at high-speed will induce vibrations, particularly on viaducts and bridges. Maglev systems are theoretically quieter than HSR.

In addition to noise, visual effects of viaducts and elevated track may also raise environmental concern and affect route designation. However, any transportation alternative is going to raise environmental questions, and the strength of specific environmental objections cannot be known without analysis on a corridor-specific basis.

A national HSR system is the centerpiece of a sustainable America, and will significantly reduce congestion and its dependence on cars and oil, while cutting carbon emissions by epic proportions. The entire system can be powered by clean, safe renewable energy including wind, solar, geothermal, and ocean/tidal. Clean electric trains are a major form of daily transportation in numerous countries, and are the single most powerful transportation choice that can solve serious mobility, energy, environmental, economic, health, and social problems simultaneously on a global scale.

9. CONCLUSIONS

While it was once the preeminent mode of travel, intercity passenger train travel in America has played a relatively minor role in the second half of the 20th century and the beginning of the 21st. Highway and aviation systems expansion and total intercity travel in the United States., has grown dramatically. Much of this growth in intercity travel has been fueled by an aggressive public investment strategy. For six decades, federal transportation policies have focused mostly on intercity transportation investment for the highway and aviation systems but not on intercity passenger trains. This is partly due to the commonly accepted myth in America that railroads can pay for themselves.

The combination of economic prosperity and a population that just passed 300 million has produced a high demand for mobility in the United States Congestion is one of the single largest threats to American economic prosperity and lifestyle and is costing America an estimated $200 billion a year. Aside from this, the heavily fossil-fuel dependent infrastructure is out of proportion and far exceeds its share for the world’s total population. The global environmental crisis is pressing the United States to find a solution to those concerns.

The United States local and federal governments are looking for solutions to try and reduce congestion but not slowing its increase. Unfortunately, the public sector has limited funds and the needs are great, despite record funding for surface transportation in recent decades. The federal government’s most important role is to establish mechanisms to ensure that the right investments are made and the HSR is often cited as a solution to many of these transportation concerns. HSR can reduce congestion on roads and airports, is cost effective and convenient, improves mobility and has environmental benefits.

Proposals for investment in HSR in the U.S. have existed for decades. However, corridor service that exceeds Amtrak’s predominant top speed of 79 mph currently only exists on Amtrak’s NEC between Boston, MA, and Washington, D.C., and in a few other corridors. By contrast, around the world HSR is proving to use safe and environmentally sustainable technologies which meet the needs of the 21st century by offering a fast, frequent and enjoyable travel alternative. Countries in Europe and Asia have developed extensive rail systems with top speeds exceeding 150 and even 200 mph, attracting a relatively high number of riders in companrison with other transportation modes.

HSR does not offer a quick or simple solution to relieving congestion on America´s highways and airways. HSR projects are costly, risky, take years to develop and build, and require substantial up-front public investment as well as potentially long-term operating subsidies. Determining which, if any, proposed HSR projects should be built will require decision makers to be better able to determine a project’s economic viability. Given the complexity, high cost and long development time for HSR projects, it will be critical to first determine how HSR fits into the American transportation system. The federal involvement baseline will be to establish a strategic vision and goals for such systems. Failure to incorporate performance and accountability measures to ensure these outcomes are achieved is a common drawback of federal transportation programs. Amtrak has attempted to fill this void to a degree but has been hampered by politics and funding issues.

While some U.S. corridors exhibit characteristics that suggest potential economic viability, determining whether any specific proposed line will be viable has proven to be difficult. This difficulty is due to the uncertainties of ridership forecasts, sponsor produced cost estimates, lack of agreement and standards regarding how a project's public benefits should be valued and quantified and the lack of comparison with alternative investments in highway or air infrastructure. At least, guidance and standards for successful models might be provided at federal level. Without this, states will continue to fill the void with a multitude of models (constitutional amendments and legislation as in Florida and California, multistate compacts as in the Pacific Northwest, public-private partnerships) without a sense of what is most likely to succeed.

A need for clarity is not only needed for the goals of a particular HSR project, but also on who is reaping the benefits. In Florida, the central concern has been who should bear the risk for a project that is described as having a public benefit but looking for private dollars. The private sector would like to see the state bear more risk, while the state would like the private sector and the federal government to assume more risk. If there are public benefits to an HSR project, then arguing for only private funding makes no sense, and such projects are unlikely to succeed. If the public benefits are questionable, then private funding is a better choice. Private sector participation is also difficult to secure without a substantial public sector commitment, both financial and political. The financial and ridership risks associated with HSR projects can also deter private entities from investing. In addition, project sponsors must coordinate project decisions among numerous stakeholders and across jurisdictional boundaries being a difficult task, especially in the absence of an established institutional framework.

More important, there is an overarching need for a national network strategy for rail (one that combines passenger, freight, and HSR). A vision for how rail connects to and interrelates with other transportation modes around the country and how it all might be funded also needs to be addressed. Otherwise, the U.S. will continue to miss critical opportunities for key linkages and enhancing efficiency, not just for HSR, but also for regular passenger rail and freight transport.

Opportunities for both incremental and new HSR exist in the U.S. and have for many years, particularly among those corridors federally designated as HSR corridors. Whether to develop a new HSR or an incremental HSR system depends greatly on what the government hopes to accomplish and the context within which they are working. If the goal is to increase the number of commuters using rail instead of automobile to minimize highway congestion, the key is to increase frequency and reliability of service, reduce travel times, and make the system more accessible. Such goals may be better met with an incremental approach that invests in station and equipment improvements, fixing curves and improving tracks, and enhancing signals, rather than new HSR. If the goal is to relieve air congestion between urban areas to free up space for more long-distance flights, a new HSR system linking key urban areas might be the better approach. However, such discussions do not always occur; often the decision to pursue one approach or another is based more on political factors than on a clear assessment and explanation of what the specific goals are and how best to meet them.

The spark for building HSR often has begun with a particular person in a particular state. The governor of Florida was the one who visited Japan and believed Florida should have a similar system. In California, several legislative leaders visited Europe and Japan and returned with the same sentiments. This year President Obama visited Spain and came back with the same enthusiastic ideas. While the initial vision is important for beginning an effort, institutionalized support is critical to sustain the effort and successfully implement HSR. Without institutional buy-in for a project, as well as the authority and responsibility to identify, gather, and manage funding, and the responsibility for and capability of seeing a project through, many HSR projects fail as soon as the key supporter or visionary is no longer involved in the project. The key will be to get at least one project fully implemented in a way that is clearly HSR (as opposed to those that are capable of high speeds but only run at such speeds for small distances). Once a project is in revenue service, many of the concerns expressed by critics will be addressed including ridership projections and whether HSR can work in a country where cars and air transport are dominant. After tackling these issues and constructing proper HSR corridors, the United States will then have the opportunity to both develop and revive domestic railcar manufacturing while maintaining the option of importing innovative international technologies.

APPENDIX

Appendix 1: High-Speed Lines in the World (Source: [F])

Continent	Country	Extension (sq miles)	Population in 2009 (millions)	Miles of HSR in operation	Miles of HSR under construction	Miles of HSR planned	Total Miles of HSR	Population Density (hab./sq mile)	Rank in Population Density
Asia	Taiwan	13,972	23	133	0	0	133	1646	1
Asia	South Korea	38,486	48	127	32	0	159	1247	2
Europe	Netherlands	16,040	17	0	46	0	46	1060	3
Asia	India	1,269,219	1198	0	0	191	191	944	4
Europe	Belgium	11,787	11	53	28	0	81	933	5
Asia	Japan	145,914	127	947	228	225	1400	870	6
Europe	United Kingdom	93,784	62	44	0	0	44	661	7
Europe	Germany	137,847	82	496	146	259	901	595	8
Europe	Italy	116,339	60	217	121	153	491	516	9
Europe	Switzerland	15,940	8	14	28	0	41	502	10
Asia	China	3,705,406	1346	321	1314	1573	3209	363	11
Europe	Poland	120,728	38	0	0	275	275	315	12
Europe	Portugal	35,556	11	0	0	388	388	309	13
Europe	France	244,310	62	723	115	1010	1848	254	14
Asia	Turkey	302,535	75	0	288	648	936	248	15
Europe	Spain	195,365	45	615	857	657	2129	230	16
Africa	Morocco	172,414	32	0	0	263	263	186	17
Asia	Iran	636,371	74	0	0	183	183	116	18
America	U.S.	3,537,437	305	140	0	347	487	86	19
America	Brazil	3,287,611	194	0	0	193	193	59	20
Europe	Sweden	173,860	9	0	0	290	290	52	21
America	Argentina	1,073,518	40	0	0	122	122	37	22
Asia	Saudi Arabia	830,000	26	0	0	212	212	31	23
Europe	Russia	6,601,665	141	0	0	251	251	21	24

Appendix 2: Cumulative Estimates of Resident Population Change for the U.S. in 2008 (Source:[G])

Cumulative Estimates of Resident Population Change for the U.S.						
State FIPS Codes	Geographic Area	Population Estimates	July 1, 2008			Future HSR Designated Corridor
		July 1, 2008	% Distr. of U.S. Total	Population Density	Area (Sq Miles)	
00	**United States**	304,059,724	100.0	86	3,531,822	
11	District of Columbia	591,833	0.2	9,687	61	
34	New Jersey	8,682,661	2.9	1,181	7,354	Northeast
72	**Puerto Rico**	3,954,037	(X)	1,155	3,424	
44	Rhode Island	1,050,788	0.3	1,016	1,034	Northeast
25	Massachusetts	6,497,967	2.1	833	7,801	Southeast & Northern New England
09	Connecticut	3,501,252	1.2	723	4,840	Southeast & Northern New England
24	Maryland	5,633,597	1.9	580	9,705	Southeast & Northeast
10	Delaware	873,092	0.3	448	1,949	Northeast
36	New York	19,490,297	6.4	414	47,126	Northeast & Empire & Northern New Empire
12	Florida	18,328,340	6.0	342	53,603	Florida
39	Ohio	11,485,910	3.8	281	40,858	Chicago Hub Network
42	Pennsylvania	12,448,279	4.1	278	44,739	Keystone &Northeast
06	California	36,756,666	12.1	236	155,766	California
17	Illinois	12,901,563	4.2	232	55,518	Chicago Hub Network
15	Hawaii	1,288,198	0.4	200	6,428	
51	Virginia	7,769,089	2.6	197	39,493	Southeast & Northeast
37	North Carolina	9,222,414	3.0	190	48,619	Southeast
18	Indiana	6,376,792	2.1	178	35,823	Chicago Hub Network
26	Michigan	10,003,422	3.3	177	56,528	Chicago Hub Network
13	Georgia	9,685,744	3.2	168	57,501	Gulf Coast & Southeast
47	Tennessee	6,214,888	2.0	151	41,235	
45	South Carolina	4,479,800	1.5	149	30,070	Southeast
33	New Hampshire	1,315,809	0.4	147	8,952	
21	Kentucky	4,269,245	1.4	108	39,492	Chicago Hub Network
55	Wisconsin	5,627,967	1.9	104	54,154	Chicago Hub Network
22	Louisiana	4,410,796	1.5	102	43,199	Gulf Coast
53	Washington	6,549,224	2.2	99	66,449	Pacific Northwest
48	Texas	24,326,974	8.0	93	261,226	South Central & Gulf Coast
01	Alabama	4,661,900	1.5	92	50,644	Gulf Coast & Southeast
29	Missouri	5,911,605	1.9	86	68,716	Chicago Hub Network
54	West Virginia	1,814,468	0.6	75	24,038	
50	Vermont	621,270	0.2	67	9,217	
27	Minnesota	5,220,393	1.7	66	79,607	Chicago Hub Network
28	Mississippi	2,938,618	1.0	63	46,920	Gulf Coast
04	Arizona	6,500,180	2.1	57	113,595	South Central
05	Arkansas	2,855,390	0.9	55	52,030	
19	Iowa	3,002,555	1.0	54	55,858	
40	Oklahoma	3,642,361	1.2	53	68,603	South Central
08	Colorado	4,939,456	1.6	48	103,641	
23	Maine	1,316,456	0.4	43	30,841	Northern New England
41	Oregon	3,790,060	1.2	39	95,985	Pacific Northwest
20	Kansas	2,802,134	0.9	34	81,762	
49	Utah	2,736,424	0.9	33	82,191	
32	Nevada	2,600,167	0.9	24	109,780	California
31	Nebraska	1,783,432	0.6	23	76,825	
16	Idaho	1,523,816	0.5	18	82,643	
35	New Mexico	1,984,356	0.7	16	121,297	
46	South Dakota	804,194	0.3	11	75,811	
38	North Dakota	641,481	0.2	9	69,001	
30	Montana	967,440	0.3	7	145,541	
56	Wyoming	532,668	0.2	5	97,088	
02	Alaska	686,293	0.2	1	570,665	

Appendix 3: Map of the United States of America (Source: [H])

Appendix 4: Groups that submitted the EOI to the FRA (Source: [EE])

Construction Groups	Country of Origin
Flatiron (Grupo Hoechtief)	USA
BOUYGUES Travaux Publics, SA	France
Ferrovial Agroman, SA	Spain
Skanska USA Civil Inc.	Sweden
FCC Construcción, SA	Spain
Balfour Beatty Rail, Inc.	UK
Peter Kiewit Constructors, Inc.	USA
John Laing USA, Ltd	UK
Bechtel	USA
Fluor Enterprises, Inc.	USA

Technology - Rolling Stock Companies	Country of Origin
American Maglev Technology (AMT)	USA
Bombardier Transportation, Inc.	Canada
TALGO Inc.	Spain
ALSTOM	France
KAWASAKI Rail Car, Inc.	Japan
SIEMENS Transportation Systems, Inc	Germany

Operating Companies	Country of Origin
SYSTRA, SA (controlled by SNCF)	France
RENFE-Operadora	Spain
First Group America	USA
Stagecoach / Virgin Group	UK
Deutsche Bahn AG	Germany
Peter Pan (Buses Operator)	USA
Veolia Transportation	France

Industrial Groups	Country of Origin
SIERAIL	USA
Sumitomo Corporation of America	USA
Mitsui & Co. USA	Japan
Hyundai Totem USA Corporation	Korea
Novi Industries, Inc.	USA
Ansaldo STS	Italy
Hitachi, Ltd (Transportation systems)	Japan
Samsung America, Inc.	Korea
SOJITZ Corporation	Japan
INDRA	Spain

Concession Companies	Country of Origin
Macquarie capital USA, Inc	Australia
CINTRA	Spain
Posco E&C “Korean Consortium”	Korea

Note: Governmental agencies and other corporations or Individuals, including small engineering groups and architects, are not included.

Appendix 5: High-Speed Rail Rolling Stock Examples (Source: [GG])

HSR ROLLING STOCK EXAMPLES				
COMMERCIAL INFO				
Maker	**ALSTOM**	**TALGO / BOMBARDIER**	**SIEMENS**	**CAF / ALSTOM**
Model	**TGV - AVE S-100**	**350**	**VELARO E**	**PENDOLINO**
CHARACTERISTICS				
Supply Voltage	25 kV AC / 3 kV DC	25 kV AC	25 kV AC	25 kV AC
Gauge	1,435 mm / 1,668 mm	1,435 mm	1,435 mm	1,435 mm
PERFORMANCE				
Max speed	186 mph (300 km/h)	218 mph (350 km/h)	218 mph (350 km/h)	155 mph (250 km/h)
Max traction power	8.8 MW	8.0 MW (2 x 4.0)	8.8 MW	4.4 MW
CAPACITY				
Typical formation	M -8R -Mc	M -12R -M	4M – 4T	4M

COMMERCIAL INFO			
Maker	**CAF / ALSTOM**	**TALGO**	**HITACHI**
Model	**ATPRD**	**250**	**700 Series**
CHARACTERISTICS			
Supply Voltage	25 kV AC / 3 kV DC	25 kV AC / 3 kV DC	25 kV AC
Gauge	1,435 mm / 1,668 mm	1,435 mm / 1,668 mm	1,435 mm
PERFORMANCE			
Max speed	155 mph (250 km/h) @ 25 kV AC 138 mph (220 km/h) @ 3 kV DC	155 mph (250 km/h) @ 25 kV AC 138 mph (220 km/h) @ 3 kV DC	177 mph (285 km/h)
Max traction power	4.0 MW @ 25 kV AC 2.7 MW @ 3 kV DC	4.8 MW	13.2 MW
CAPACITY			
Typical formation	Mc -M -M -Mc	M -11R -M	12M – 4T

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ACRONYMS

ADIF	Administrador de Infraestructuras Ferroviarias
ARRA	American Recovery and Reinvestment Act
ATP	Automatic Train Protection
BNR	Burlington Northern Railway
BOO	Build Own Operate
CCAP	Center for Clean Air Policy
CREATE	Chicago Regional Environmental and Transportation Efficiency Program
DBB	Design-Bid-Build
DBFM	Design Build Finance Maintain
DBFMO	Design Build Finance Maintain Operate
DOT	Department of Transportation
EDS	Electrodynamic Suspension
EIB	European Investment Bank
EIS	Environmental Impact Study
EMS	Electromagnetic Suspension
EOI	Expressions Of Interest
ERDF	European Regional Development Fund
FDOT	Florida Department Of Transportation
FHSRA	Florida High Speed Rail Authority
FHSRC	Florida High Speed Rail Committee
FHSRTCA	Florida High Speed Rail Authority Commission Act
FHWA	Federal Highway Administration
FOX	Florida Overland Express
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
GAO	Government Accountability Office
GHG	Greenhouse Gas
HSGT	High Speed Ground Transportation
HSR	High Speed Rail
ICE	Inter City Express
ISTEA	International Surface Transportation Efficiency Act
JNR	Japanese National Railways
JR	Japan Railways
LIM	Linear Induction Motors
LSM	Linear Synchronous Motor
MAGLEV	Magnetic Levitation
MOU	Memorandum of Understanding

MWRRI	Midwest Regional Rail Initiative
NEC	Northeastern Corridor
PPF	Public Private Financing
PPP	Public Private Partnership
PRIIA	Passenger Rail Investment and Improvement Act
PTC	Positive Train Control
RENFE	Red Nacional de los Ferrocarriles Españoles
RFEI	Request For Expressions of Interest
RFF	Réseau Ferré de France
RFP	Request For Proposal
RFQ	Request For Qualifications
ROW	Right-Of-Way
RRIF	Registered Retirement Income Fund
SHSRC	Southern High Speed Rail Commission
SNCF	Société Nationale des Chemins de Fer Français
TEA-21	Transportation Equity Act for the 21st Century
TGV	Train à Grande Vitesse
THSRA	Texas High Speed Rail Authority
THSRTC	Texas High Speed Rail and Transportation Corp
TIFIA	Transportation Infrastructure and Innovation Act
TXDOT	Texas Department Of Transportation
U.S.	United States
USA	United States of America (same as U.S.)
WSDOT	Washington Department Of Transportation

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